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STUDENT PAPERS

on

STRATEGIC

DEFENSE

INITIATIVE

UNITED STATES AIR FORCE ACADEMY

1985

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UNITED STATES AIR FORCE ACADEMY

STUDENT PAPERS

on

STRATEGIC DEFENSE INITIATIVE

ISSUES

May 1985

PREFACE

The papers and thoughts contained in this volume are a result of the work of students enrolled in an interdisciplinary seminar class on strategic defense issues. The course was sponsored by Maj Lawrence Baker, Joint Analysis Division, Joint Chiefs of Staff. The primary instructors for the course were assistant professors from the Department of Astronautics. Several other members of the Academy faculty staff from the departments of Physics, Political Science, and Management helped in administering the course.

This volume is organized into two sections. The first section contains individual student papers. Each student in the course was asked to research a topic or issue of interest in strategic defense. The papers focus on the management and organization, the technical, and the political issues of the United States's strategic defense program.

The second section is a collection of five group papers written by the students as final reports. Three of the students, Cadets Sean Roche, Gary Konnert, and Michael Healy, briefed the Office of the Joint Chiefs of Staff at the Pentagon in May 1985 on their group findings.

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A special thanks to Mrs. Kay Richard, Department of Astronautics, for providing the administrative help in publishing these papers.

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CONSIDERING COUNTERMEASURES

by

Cadet Dale R. Huhmann

2 March 1985

ABSTRACT

The Strategic Defense Initiative (SDI) will be effective only if the Soviet Union cannot negate the defense system with countermeasures more cheaply than the U.S. can maintain the system's viability. Opponents of SDI feel that the Soviets will always be able to develop effective countermeasures (i.e. decoys, ASATs, fastburn boosters, and passive means). Proponents are confident American technology will be able to negate any Soviet attempts of thwarting SDI. This debate is complex and not easily solvable. This paper presents both sides of the debate. Discussion concentrates on the technical aspects associated with possible countermeasures deployable by the USSR and possible counter-countermeasures used by the US

CONSIDERING COUNTERMEASURES

The Strategic Defense Initiative (SDI) was conceived by President Reagan "to give us the means of rendering nuclear weapons impotent and obsolete."[1] The President expressed the hope that a technological revolution would enable the U.S. to "intercept and destroy strategic ballistic missiles before they reached our own soil or that of our allies."[2] If such a breakthrough could be achieved, he said, "free people could live secure in the knowledge that their security did not rest upon the threat of instant U.S. retaliation."[3]

I agree with the President that an effective, fully deployed US ballistic missile defense could significantly reduce the military value of Soviet pre-emptive attacks, thus increasing both deterrence and strategic stability. However, such a defense could remain effective only if the Soviet Union cannot negate the system with countermeasures more cheaply than the US could maintain the system's viability.[4] Consequently, we don't know whether defensive systems are effective until countermeasures are examined and proven more difficult to design and deploy than the defensive measures themselves.

Critics of SDI claim that every defensive system could be effectively nullified with countermeasures which include decoys, fast-burn boosters, anti-satellite weapons, passive protection devices and poliferation of offensive weapons. Proponents, on the other hand, feel that technology will eventually overcome any and all countermeasures. One thing is certain: if we deploy SDI, the Soviets will deploy countermeasures. Two top ranking Soviet specialists in missile and space technology assured the US that the Soviet Union would counter any threats to the survivability of their ICBM forces.[5]

There are many effective countermeasures which can be employed. For instance, Richard D. DeLaurer, Under Secretary of Defense for Research and Development, feels that "any defensive system can be overcome with proliferation and decoys."[6] For example, each Soviet ICBM bus could dispense as many as 100 empty aluminum mylar balloons weighing only 100 grams each. These decoys would have the same optical and microwave signature as the warheads, thus the defensive system's sensors would not be able to distinguish between them, making post-boost intercept and destruction far more difficult.[7] As Lieutenant General Abrahamson pointed out, differentiating between warheads poses an "awesome" task.[8]

Another countermeasure related to decoys is poliferation. Oversaturation of the defensive system's capabilities in tracking and eliminating ICBMs can be quite effective. The USSR could add enough missiles and decoys to its attacking force to ensure penetration of any US strategic defense system.[9] Saturation is especially effective if offensive weapons and decoys cost less to produce than space-based defenses. Additionally, as strategic defenses force the "cost-per-delivered-warhead" to rise, the Soviets might respond with an increased emphasis on submarine-launched ballistic missiles (SLBMs), bombers, and cruise missiles.[10] Consequently, the USSR might effectively sidestep the ballistic missile defense system altogether.

ASAT weapons, such as orbiting lasers and space-based nuclear mines, could threaten strategic defense assets. Key defensive satellites could be knocked out, punching a hole through the US defenses and allowing a majority of Soviet ICBMs to reach their targets.[11]

Fast-burn boosters could be used to decrease the number of ICBMs intercepted during the boost phase. These boosters, with shortened boost times and lower burnout altitudes, would allow less opportunity for boost phase intercept weapons to acquire and destroy them. Fast-burn boosters

would therefore be an effective, even decisive, countermeasure against almost all boost phase intercepts.[12] It is important to have an effective defense during boost phase since target acquisition and tracking becomes many times more complicated after the reentry vehicles are released. Once the individual weapons are released, the number of targets increases by a multiple of up to 10. In addition, if decoys are also deployed, the number of targets increases by another factor of up to 100 since it is possible to deploy as many as 100 decoys per warhead.

Finally, the Soviets could use "passive" means to counter US strategic defenses. One possibility includes spinning the ICBM so that directed-energy weapons such as lasers lose effectivity. Spinning prohibits the laser from depositing its energy in any one spot on the booster for any length of time.[13] In addition to spinning a booster, ablative heat shields could be used to absorb energy deposited on the missile by laser systems.[14]

Because of these and other examples of countermeasures, critics of SDI believe that the Soviets will find the necessary solution to accomplish their goal of maintaining a credible warfighting capability. Thus, critics of SDI feel further pursuing SDI research is a waste of time and money.

On the other hand, proponents of SDI say that countermeasure effectiveness has been largely exaggerated. According to the Fletcher panel, there are "ways to counter every countermeasure the offense may choose to make. Whether these defensive measures are cost-effective or technically feasible is a major research objective of the SDI."[15]

Today's technology can nullify many of the countermeasures previously discussed. Using multispectral sensing of incoming objects with laser imaging and millimeter-wave radar, we can identify decoys through all phases of the trajectory, and use kinetic-energy weapons to overcome the difficulties of midcourse target identification and intercept.[16]

Fast-burn boosters do not pose any serious problems. Department of Defense analysis suggests that the Soviets could not develop the technology to deploy such boosters until some time after the turn of the century.[17] Additionally, fast-burn boosters reduce missile throw weight by an average of between seventy and ninety percent compared to an equivalent standard missile.[18] Such a large reduction in throw weight could ease the task for defensive systems to target enemy missiles in the midcourse and terminal phases.

Countering ASAT weapons will depend on hardening technology

or the establishment of "no-trespassing" zones. Hardening satellites, especially fragile mirrors and sensitive antennas, against lasers and nuclear weapons is a complex problem that will take years of research to solve. However, a more likely solution is declaring "no-trespassing" zones (i.e. 100 km. radius around battle stations).[19]

Finally, passive countermeasures are of little value since they reduce the efectiveness of the Soviet offensive forces. Ablative material, spread over a Soviet SS-18 to protect it from laser energy, would weigh two grams per square centimeter. This coating, spread over the upper two-thirds of the SS-18 would weigh 4.8 tons! Since the payload of the SS-18 is eight tons, such a countermeasure would reduce the efectiveness of this largest element of the Soviet ICBM arsenal by 60 percent.[20] In addition, rotating the missiles might add only a fraction of a second to the time required to kill the ICBM.[21] Using other passive measures, such as insulation, involves structural and aerodynamic problems that yet need to be solved.[22] Thus, it can be said there are few, cheap and easy countermeasures.

As is evident from the proceeding discussion, the debate concerning countermeasures is complex. Opponents to SDI feel that the Soviets will always be able to develop

effective countermeasures (i.e. decoys, ASATs, fast-burn boosters, pasive means, and others not yet conceived). Proponents are confident that "good-old American Yankee know-how" will be able to nullify any Soviet countermeasure. I feel it is too early to pass judgment on these issues. The purpose of SDI is to resolve these questions. Consequently, the SDI research should continue until not only the countermeasure issue is resolved, but until all major questions (costs, effectiveness, policy, etc....) concerning the feasibility of a strategic defense system are answered.

FOOTNOTES

1. Hans A. Bethe et al., "Space-Based Ballistic Missile Defense," Scientific American, Oct. 1984, p. 39.

2. Bethe, p. 39.

3. Bethe, p. 39.

4. U. S. Department of Defense, Defense Against Ballistic Missiles, (Washington D. C.: U.S. Government Printing Press, 1984), p. 3.

5. "Soviet Experts Issue 'Star Wars' Warning," Los Angeles Times, 14 May 1984, p. 4.

6. Bethe, p. 47.

7. Bethe, p. 42.

8. Edgar Ulsamer, "Charting a Course for SDI," Air Force Magazine, Sept. 1984, p. 117.

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10. Bethe, p. 41.

11. Ashton B. Carter, Directed Energy Missile Defense in Space, (Washington D.C.: U.S. Government Printing Press, 1984), Background Paper, p. 47.

12. Carter, p. 49.

13. Carter, p. 49.

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15. Whitt Flora, "Administration Defends ABM Program," Aviation Week and Space Technology, 14 May 1984, p. 24.

16. DOD, "Defense Against Ballistic Missiles," p. 16.

17. Ulsamer, p. 108.

18. Ulsamer, p. 111.

19. Carter, p. 47.

20. "Scientists Say SDI Scientifically/Technically Feasible," Defense Daily, 20 July 1984, p. 101.

21. Angelo Codevilla, "Understanding Ballistic Missile Defense," Journal of Contemporary Studies, Winter 1984, p. 32.

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THE FREE ELECTRON LASER

for

BALLISTIC MISSILE DEFENSE

by

Cadet Terrence A. Leary

3 March 1985

THE FREE ELECTRON LASER

Laser research began about two decades ago. The search for the more powerful, more efficient laser continues with renewed emphasis ever since President Reagan's "Star Wars" speech on 23 March 1983. But why are people interested in a device that can only use about ten percent of the energy required? The answer is that it takes great amounts of energy to produce a force on the electrons. Even though the efficiency is low, the energy output is in an extremely usable form, and in very powerful, concentrated amounts. It's the focused and concentrated energy that scientists hope to use as a weapon in a possible ballistic missile defense system presently researched by the Strategic Defense Initiative Organization.

Before any laser weapon system can be developed, many problems need to be solved. One problem addresses the system basing mode. There are two general theories. One theory recommends space-based lasers independent of ground requirements. This theory however encounters a problem of lifting heavy payloads into orbit. The other theory would require ground-based lasers and use space mirrors to aim the beam at the target. This option has several problems. First, beam intensity attenuates by the inverse of the distance squared.

Secondly, only certain wavelengths can get through the atmosphere with minimum attenuation. Thirdly, laser wavelengths change with changing atmospheric and weather conditions.

There are two ways a laser can destroy a ballistic missile. One way is through a continuous beam which heats up the skin of the missile and causes a catastrophic failure. The other method is by using a pulsed laser beam which hits the missile in short powerful bursts creating a shock wave that "resonates" through the missile causing equipment failure. The pulsed laser beam requires much less energy than a continuous beam and can achieve higher intensities. The free electron laser is a pulsed laser.

My purpose in this paper is to look at how the basic laser operates and to see how the free electron laser can overcome the common laser problems to be considered a possible ballistic missile defense weapon.

Laser stands for Light Amplification by Stimulated Emission of Radiation. All lasers are built to operate under the same basic principles. I will present, step-by-step, the basic processes essential to all lasers.

In order to develop the laser, radiation must be produced.

The radiation comes from raising electrons to excited states and letting them fall back to their normal or ground state E_1 through the emission of a photon of radiation. The electrons used are part of a molecule which already has certain defined energy levels. A pump or some other source of energy is required to raise the electrons to the excited state: the E_4 state. Once electrons are at the excited E_4 state, they drop back to the ground state, spending a nominal 10^{-8} seconds in each state on its way back to ground. Thus the electrons quickly drop to the E_3 level emitting a photon of radiation whose wavelength (λ) is determined by the energy difference between levels according to the formula $E = \frac{hc}{\lambda}$. In this equation h and c are constants. (4) The emitted radiation however, is not the laser radiation we are interested in. Once the electrons drop to energy level E_3, they reach a metastable state which means that instead of staying in the state for the normal 10^{-8} seconds, the electrons remain in the E_3 state for 10^{-3} seconds, or 10^5 times longer than the other states. The metastable E_3 state maintains a much larger population of electrons at the higher energy level than at a lower level. The large population of electrons is maintained because when the electrons do drop out of level E_3 they only stay in level E_2 for the normal 10^{-8} seconds before falling to ground or level E_1. Lasing occurs between levels E_3 and E_2. (4)

(4)

When a photon passes in the vicinity of an electron one of two things will happen. The electron will absorb the photon, adding energy to the electron and raising it to a higher energy level; or the photon will cause the electron to drop to a lower energy level and emit another photon. The probability of either of these events happening is equal. However in a large population, more of the electrons will drop to the lower level and emit photons. Since all the electrons in one state drop into the same energy level, they all have the same energy, wavelength, phase, and direction. This proces is called stimulated emission and produces the coherent radiation for the laser. The stimulated emissions tend to be released equally in all directions, therefore, they need to be focused to produce the laser. To accomplish focusing two mirrors are placed at the end of the laser. One mirror reflects 99% of the radiation while the other reflects about 40% . Thus when some of the photons are emitted parallel to the laser mirrors they are bounced back and forth causing other photon to become parallel to the mirrors. This process creates the amplification of the laser radiation. The 40% reflective mirror allows 60% of the laser radiation to "leak" pass the mirror resulting in the laser beam. (4) The wavelength of the beam can vary

from far infrared to x-ray depending on the energy difference between the metastable state and the next energy level. The wavelength however is generally fixed for each specific laser.

The free electron laser uses the same basic principles to produce its radiation, but it has one major difference. Instead of using electrons attached to molecules which have defined energy levels, it uses "free" electrons that are not attached to any molecule. There are two typical sources for these electrons. The first source of free electrons is an electron accelerator; the other source is a storage ring of electrons. The advantages of a storage ring are that it has a higher density of electrons and it reuses the electrons. This allows the free electron laser to achieve much higher efficiencies of energy input verses energy output. (3:670)

The "free" electrons from either source are shot through a wiggler magnetic field which produces a sinusoidal polarization. (1:33) As the electrons pass through the wiggler field, their motion becomes sinusoidal. The sinusoidal motion serves as the pump. The electrons oscillate between energy levels to produce the stimulated emission. Amplification is achieved by using mirrors and by increasing the number of electrons passing through the field.

An important note about the free electron laser is that the wavelength is determined, not by the quantized energy levels, but rather by the strength of the electron beam, the spacing of the wiggler magnets, and the strength of the wiggler field. (6:937) Consequently, the free electron laser is tunable, that is, its able to achieve different wavelengths from the same laser. Any or all of the three parameters which control the wavelength, as mentioned above, can be adjusted to change the wavelength according to the formula: (2:119-120)

where Λ = period of wiggler field

λ = wavelength

$$\gamma = \frac{\text{total energy of } e^-}{\text{rest energy of } e^- \text{ (511kev)}}$$

Several problems with the free electron laser are now being resolved. One problem involved the huge currents needed in the windings to produce the wiggler magnetic field. This problem was solved by using a new form of wiggler field produced by alternating somarium-cobalt magnets. (1:33) Another problem involved the reflecting of ultraviolet and x-ray radiation produced by the free electron laser. A new layered material was found that can reflect these wavelengths. (5:278)

The free electron laser is a high-powered, pulsed laser that has the ability to change wavelengths. Since free electron lasers are still in the early stages of development, I'm lead to believe that the free electron laser is one of the best alternatives for a ground-based laser in ballistic missile defense. The laser would have to be ground-based because of its weight and our limited space launch capabilities. However, if the efficiency of the laser were improved to 30-40 percent from the current rating or if a dramatic increase occurred in US space launch capability, the free electron laser would become a viable space-based system. It is for these reasons that I believe the free electron laser should be considered for a ballistic missile defense system.

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ANTIMATTER: A VIABLE SDI OPTION?

by

Cadet Jeffrey S. Henry

4 March 1985

ANTIMATTER: A VIABLE SDI OPTION?

On 23 March 1983 President Reagan submitted his Strategic Defense Initiative proposal to the American public and the rest of the world. Immediately, the idea drew heated criticism from various groups, and, in some cases, still does. Despite opposition, the research program continues. One of the first steps in the program taken by the Reagan administration was the formation of the Defensive Technology Study Team, headed by former NASA administrator James C. Fletcher. Meeting with the National Science Foundation, National Academy of Sciences, and other groups, the "Fletcher Committee" explored new ideas for defensive technologies and structure for the SDI program.

The Fletcher Committee's report ultimately stated that:

> Two new ideas surfaced that warrant serious attention and fiscal support in the years 1984 to 1989.... The first of these was the possible use of extraterrestrial resources.... The second idea is that <u>antimatter beams could provide an effective and highly lethal kill mechanism</u>.

This quote from the committee's report appeared in the 17 October 1983 issue of <u>Aviation Week and Space Technology</u>, but does not appear in the unclassified version of the Defensive Technology Study report. In fact, no reference at

all is made to antimatter or antimatter systems.

According to page 19 of the magazine issue, the Rand Corporation, a U.S. Government think-tank, proposed the idea of using an antimatter beam as a directed energy weapon, or directed "anti-energy" weapon.

While the concept of antimatter was once just a possibility in science fiction, scientists in the United States, Europe, and the Soviet Union have been able to produce antimatter in "some quantity" and have also developed the means to store it.[1] Once again, Aviation Week and Space Technology attributes this information to the Fletcher Committee report, but it cannot be found in the unclassified version.

The production of antimatter is undertaken only in the most advanced particle accelerators such as the Fermi National Accelerator Laboratory in Batavia, Illinois, and the Centre European pour la Recherche Nucleaire (CERN) in Geneva, Switzerland.[2]

When a radioactive element decays, it emits α and β particles, which are essentially helium nuclei and electrons, respectively. For example, the β -particle can be released as a β^+ or a β^-. Remembering that a β particle is an

electron and has a negative charge; a β^{+} then is foreign to what we know to be true. A β^{+}, or e^{+}, is an anti-electron, or positron, and is one result of two basic β decay processes:

$$\text{proton} \text{ ---> } \text{neutron} + e^{+3}$$

This formula shows that, like a photon, a positron is created, rather than being a "part" of the proton. The sister particle of the positron is the antiproton, or p^{-} , and is substantially more discrete than the positron. Since a proton is approximately 2000 times heavier than an electron, it is logical to assume that they require much greater particle accelerator energies to keep them separate and prevent reactions.

The interaction of matter with antimatter produces the annihilation of a mass equal to that of the smallest mass involved. This annihilation produces incredible amounts of energy according to Einstein's famous $E = mc^2$ equation. For example, consider the reaction of a proton with an antiproton:

$$m_p = 1.67 \times 10^{-27}\text{kg} \qquad C = 3 \times 10^{8} \text{ m/s}$$

$$E = 2(1.67 \times 10^{-27} \text{ kg})(3 \times 10^{8}\text{m/s})^2 = 3.006 \times 10^{-10} \frac{\text{kg m}^2}{\text{s}^4}$$

$$(3.006 \times 10^{-10} \frac{J}{s^2})(\frac{1 \text{ ev}}{1.602 \times 10^{-19} \text{ J}}) = 1.8757 \times 10^9 \text{eV/s}^2$$

$$= 1.9 \text{ GeV/s}^2 \text{ of Energy}$$

These figures are important in terms of the energy produced by matter/antimatter reactions. The possibilities appear to be considerable.

The Rand Corporation suggests using a space-based particle accelerator with very low energy requirements to produce an "antimatter beam at 4-20 MeV."[4] Rather than using the semi-transparent mirror to allow coherent light to exit as a laser beam, the accelerator weapon would use magnetic fields to direct and form a beam.

By using superconducting magnets and a low current according to the equation:

$$\overline{F} = q\overline{E} + q\overline{V} \times \overline{B}$$

the antimatter particles will be accelerated into a beam by circulating them around a closed loop circuit. Each revolution increases the energy, until a maximum level is reached. Once this maximum level is reached, the loop is opened and the particles escape as a pulse of energy. The Fermi Labs have achieved pulses of approximately 10^{13} protons.[5] If a

steady pulsed beam of antimatter impacts a target vaporizing atoms on a 1:1 basis, and releasing 1.9 GeV per proton/antiproton reaction, a target could be annihilated instantly. Assume 1000 pulses of 10^{10} antiprotons impacting a target (i.e. 2000 pulses/second) in a half of a second. If this energy were applied for two seconds, 12,000 Joules of energy would vaporize the target. The rate of 1000 pulses a second of antiprotons is not at all unrealistic since the development of antiprotons parallels the development of photons for lasers.[6]

Antimatter beams are not the only application for antimatter systems. A type of matter/antimatter bomb could also be made. After synthesizing a small quantity of antimatter in a particle accelerator, it could be channeled into a small ring formed by interacting magnetic and electric fields. The magnetic field would be of magnitude [$\overline{B}$] , oriented toward the ring's center. An electric field would be oriented obliquely, with a top-to-bottom component equal to [$\overline{B}$] and a very slight component in the same direction as $\overline{B}$. Consequently, a net force results toward the center of the ring. The velocity of the particles in the ring would oppose the centripetal force, and therefore "orbit" a central point. The vacuum of space would enhance this entire process. By disrupting any of the fields' components the

antimatter would scatter and contact with the matter around it resulting in the release of huge amounts of energy.

This type of bomb could be used as a space mine, a warhead, or a projectile in a kinetic energy weapons. If used as a projectile, an electrically shielded casing could be placed around the antimatter ring with a North-South polarity equal and opposite to that of the kinetic energy weapon. Once fired, the projectile would shed its casing. As the projectile neared a target, the delicately tuned fields separating matter and antimatter would act as a proximity fuse. When the field is disrupted by the slightest electric or magnetic "noise" from the boost vehicle, post-boost vehicle, or reentry vehicle, the bomb would detonate.

Another idea for using antimatter is to form a plasma of antimatter similar to "ball lightening" or static electricity. Propelling the plasma in the direction of the target would almost ensure impact. Any target passing through the plasma would be vaporized, and would release enough energy to affect other nearby targets.

Can a countermeasure be developed against antimatter weapons? If an antimatter beam were composed of charged particles, it could be deflected or even repelled by a

strong magnetic or electric field. But a strong magnetic or electric field would disrupt guidance and control systems needed by the targets. Production of these fields would also require considerable weight and space, reducing the utility of each boost or post boost vehicle.

I presented a few ideas on possible uses for an antimatter weapon system. They are conjunctural and based on the most rudimentary understanding of the physics involved. I hope to find out more on the subject and possibly pursue it further.

FOOTNOTES

1. "Scientific Canvas Locates Innovative Defense Ideas," Aviation Week and Space Technology, 120, 17 October 1983, p. 19.

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4. Halliday, p. 548.

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AN ANALYSIS OF THE COST ESTIMATING PROCESS

for the

STRATEGIC DEFENSE INITIATIVE

by

Cadet Sean P. Roche

4 March 1985

AN ANALYSIS OF THE COST ESTIMATING PROCESS

After the many technical questions posed by the Strategic Defense Initiative (SDI) have been answered, the next step becomes evaluating the system's worth in light of its overwhelming cost. First, we must gain an appreciation for the size of this program. The Council of Economic Priorities reports that: "The total program could cost 400 to 800 billion dollars if it goes directly into full scale development after the current 5 year R & D phase." (2:1) When considering the magnitude of current deficit spending, it is easy to see how cost overruns in a program this size could have a devastating effect on our economy. According to Senate Majority Leader Robert Dole:

> Only a very small group of people believe that the economy can grow out of the deficit problem. The government can't live on the credit card forever. The fastest growing program in America is not agriculture, not medicare, not defense. Its the 154 billion dollars of interest payments on the debt in the '86 budget. (5.74)

The pinnacle of the SDI program will not be the solution to certain technical restraints but rather the decision of whether or not to appropriate funds for the exploratory development phase. In order to accomplish this crucial step, accurate and reliable cost estimates must be available to the decision makers and acquisition planners in the military. "Adequate cost estimating depends on the availability

of people and methods for making cost estimates." (3:154) It also relies on the utilization of modern techniques for ensuring reliability.

At this point, it's important to differentiate between cost and price. Price refers only to the contractor's cost without any regard to the negotiated profit. However, the term cost is generally used to denote the contractor's expenditures as well as the predetermined level of profit. (3:155) Valid estimates provide a reliable basis for deciding what systems are to be developed and whether a program should be continued, modified, or stopped. According to a recent professional study on cost control, there are a number of reasons for poor cost estimating on major programs in the Department of Defense. They are:

1. Improper task identification.
2. Accepting estimates from only one source.
3. Lack of adequate data.
4. Inadequate prediction and preparation of program uncertainty.
5. Lack of organized estimating procedures.
6. Biased review of estimates. (2:12)

There are essentiality three types of cost estimates. The

first type are parametric. The fundamental concept behind this type of estimating is to use data from previously constructed systems to predict the cost of future systems based on certain parameters. The most important characteristic of the parametric inputs is that of inter-relationship. A change in any one parameter is usually not localized to one cost element but rather may have a direct effect on several cost elements and an indirect effect on many more. (3:156) A typical parametric model contains thousands of mathematical equations relating input variables to cost. This estimating technique is most effective when there is a limited amount of engineering analysis available.

Parametric estimating also exhibits several shortcomings. "Since they are based on the actual cost of previous systems, they can be no better than the historical data used as input." (3:154) Also since SDI is utilizing the foremost technology, the models may be obsolete by the time they're used. (3:157) There are a number of pitfalls that specifically apply to the Strategic Defense Initiative Program. First, the data used may not be updated to reflect an efficiency or learning. In addition, since many of these elements have never been purchased and in the light of the extreme technical advances they involve, the risk which must be assigned to the various elements of the estimate is

increased and thus they are each more vulnerable to errors in accuracy. Finally, with the increased amount of technological risk, the subjective element is increased and the importance of a totally non-biased estimator becomes even more essential.

A second type of estimating technique is the engineering estimate. These provide the grounds for estimating cost by dividing the proposed system into many subcomponents and analyzing the specific work to be performed for each, or by using parametric estimating techniques on a system that has been broken down. They are tailor made to meet the requirements of a specific program; thus, the margin of error is less than it would be for parametric estimates. (3:157)

An engineering estimate is not without shortcomings. "It involves many detailed analyses and runs the risk of becoming inflated through failure to identify the contributions of managers at each level of summation." (3:157) There are also several problems with this type of estimate as it applies to SDI. First, experience in large acquisitions programs such as SDI has indicated that the Department of Defense does not analyze contract proposals well, especially in predicting cost overruns. DOD officials are likely to be overly optimistic and biased towards this type of estimate

especially in light of the pressure to get this program completed. Secondly, the secrecy of the SDI program places further restrictions on the already limited competitive nature of bids and thus reduces any basis for comparison based on engineering approaches.

The third type of cost estimate is the learning curve estimate. The basic premise behind this type of estimate is the cost of identical units produced in volume in the past. Over time it is expected that the cost per unit volume will drop based on greater efficiency with increased quantity. The advantage of these estimates is that they are easily formulated and used. (3:157) The disadvantage is that these estimates "project past experience into the future, whether or not that experience is based on reasonable and efficient operations." (3:157) These estimates are used for the production phase which will only occur for the elements of SDI which involve several identical units. An example of this would be a radar-homing terminal defense system proposed by the Homing Overlay Experiment. A defense system such as this would require a degree of saturation that involves large numbers of systems.

Thus we have the tools to get the job done, but we are faced with considerable problems. We should begin by realizing

that no single estimating technique will solve all of the problems posed by SDI. The best approach may be to use parametric and engineering estimates in a combined approach that establishes a system of checks and balances which utilizes independent should-cost estimates and analyses. For this type of combined approach, several steps must be taken. First there needs to be a firm requirement up-front to identify potential problem areas. While the technical aspects and problem areas have been addressed, the potential cost assessment problems need to be accounted for. Secondly, the requirements and objectives of the program need to be specifically identified to avoid spending large amounts of money without any direction. A third possible area for reform is in the planning process. Milestones for both performance and cost, and procedures for rectifying inconsistencies existing in the present program should be established. Finally, and most importantly, there needs to be integrity within the command structure. When all factors would lead the informed, rational man to believe that the SDI program is not feasible, the commanders at various levels should, based on the information provided by cost estimates, recommend not to continue with the program. (4)

Thus we have examined one small aspect of the SDI program, that is, the cost estimating process. We must account for

the problems of cost estimating and deal with them in an effective manner to help determine the likelihood of success. A program this important to our nation's national security must not escape any aspect of critical analysis.

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SDI AND ARMS CONTROL:
TRADING SOMETHING FOR NOTHING

by

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4 March 1985

SDI AND ARMS CONTROL

The interrelationship that exists between the Strategic Defense Initiative and the topic of arms control represents just one of the program's many issues that will be addressed for the first time in the next few years. The January 1985 Geneva agreement to resume arms control talks between the US and the Soviet Union has raised a great many questions and debates over whether the US could or should attempt to use the program as a "bargaining chip" to gain concessions from the Soviets.

SDI is currently a research program designed to determine the feasibility of a drastic shift in defense policy. Due to its experimental nature, the Reagan administration has asserted that the program will not be up for negotiation - not yet, at least. If, after intensive research, it is determined that the program is feasible, President Reagan has said that he would be willing "to go into negotiations about....whether and how to deploy." (1:32)

The purpose of this paper is to outline the reasons the United States should not enter into negotiations to eventually discard SDI now or in the future. Several problems will be briefly discussed in an attempt to understand the

dangers to the national security of the United States this issue poses.

The success or failure of any arms control agreement depends on the intentions and sincerity of the parties involved. In assessing the utility of an agreement, US negotiators need to know what the Soviets expect to gain from the agreement ahead of time. If the Soviet are planning to gain concessions from the US while giving very little in return, then the utility of any agreement reached, from a western point of view, is bound to be very low.

To accurately assess Soviet intentions, the first place to look would be to the history of arms control over the past twenty years. In a recent interview with Seymore Weiss, the former Director of the State Department's Bureau of Political and Military Affairs, <u>US News and World Report</u> illustrated his opinion of Soviet intentions:

> If you look at the history of arms control over the past two decades, there's absolutely no evidence that we can get a major agreement with the Soviets involving nuclear arms that is equitable and in American national interest. The reason for this is obvious. The Soviets do not even accept the concept of equality as it is normally understood. They demand what they call "equal security" which turns out to mean a Soviet nuclear capability superior to the combined capability of all other nuclear powers--not just the United States but Britain, France, and China, as well. (2:33)

It is logical to question why the Soviets would demand such a capability for themselves. Such a capability, were they to attain it, would be far in excess of what was needed for ordinary national security. The answer to this question lies at the heart of Soviet national objectives, according to Weiss:

> Basically, the US and Soviet national objectives are sharply juxtaposed. In the case of the Soviets, military power, including nuclear power, is the single most important factor underlying what the Soviets call "correlation of forces," which they believe must be in their favor if they are to pursue successfully their objective of a world pliant to Moscow's preferences. As they see it, they need this favorable correlation of forces for several purposes: To support revolution, which they call "wars of national liberation" in Third World areas; to invade neighbors, as is currently the case with regard to Afghanistan, or to attempt political intimidation of Western Europe, which we most recently witnessed in the controversy over the deployment of American Pershing II and cruise missiles in Europe...The Soviets simply do not give away in negotiations advantages which they do not believe they can be forced to give up in the ongoing political contest. (2:33)

These types of Soviet national objectives would not appear compatible to any type of arms agreement where the good intentions and sincerity of both parties was critical. History, then, seems to tell us that the United States can never really expect to sign an agreement in which the Soviets perceive to have sacrificed any real military capability. It's strange that it would turn out that way; for the utility of any arms control agreement can be measured in

terms of reductions in real military capability on both sides.

There is another problem associated with Soviet intentions: that of treaty compliance once an agreement has been signed. Colin S. Gray, in his book, American Military Space Policy, summarizes the dismal Soviet compliance record:

> Historically, Soviet behavior while under international legal constraint has reflected an attitude of caveat emptor. Soviet officials not only act on the principle that all that is not explicitly prohibited is permitted when it serves their interests, they also believe (as reflected in their actions) that it is their duty to violate agreements when it is in the Soviet interest to do so, if they can get away with it. "Getting away with it" may mean either that the US is unlikely to be able to detect the violation with confidence, or that the US will choose to dismiss the detected violations as being of trivial significance and will, in effect, condone them. (3:76)

The bottom line on Soviet intentions seems to be this: if a proposed arms agreement is not going to help their military capability, they will not sign it. If a signed agreement no longer suits Soviet interests, they will violate it. The United States simply cannot afford to continue dealing on a diplomatic level of "good intention" with an adversary whose intentions are not the same.

To the government of the Soviet Union, arms control represents another instrument of national power through

which they can further their progress toward the achievement of national objectives. The reason this is so can be attributed to the basic differences that exist between the Soviet society and ours. The Soviet Union is a closed society represented by a government which can easily find and adhere to a consensus; the United States, however, is an open society represented by a pluralist government which rarely, if ever, settles upon a true consensus. This uncertainty is a characteristic of the United States that the Soviets hope to exploit. In an arms control negotiation situation, the open society of the United States is an inherent disadvantage as is outlined by Weiss:

> Negotiations of the sort that we're talking about are bound to stretch out over a period of years. It would be my prediction that during these protracted negotiations, voices will soon be raised in our own councils that will say that we should not proceed with Star Wars, MX, antisatellite capabilities or the Midgetman missile or other such programs because that may prejudice the outcome of ongoing negotiations. The Soviets do not have that problem. And this is where the asymmetry of the two societies comes into play. I prefer our society to their's, but in this case it happens to work against us. They can and do sit at the table and say "Nyet" and hold their position, whereas the dynamics in our own society creates pressure to get an agreement, to make concessions while our own defense programs are brought to a halt. Therefore, the Soviets may well calculate they can gain concessions from the US without giving up very much. (2:34)

Other characteristics of western society work against the US in the arena of arms control. Again, these disadvantages

are closely linked to the political structure of our respective governments. First, NATO is more easily divided on arms control issues than members of the Warsaw Pact. The resulting squabbling weakens our position. Secondly, Gray points out "...in a democracy, an arms control process serves too easily as an alibi for laxness in defense preparation...". (3:76) This indicates that negotiations often will passify western nations and lull them into a false sense of security. Gray says that it "...may help foster a climate wherein western politicians, officials and other opinion-leaders believe that the Soviet Union poses less of a threat than was formerly thought to be the case." (3:76) A final characteristic of our society which works against us involves a democracy's apparent impatience for visible, tangible progress while negotiations are underway:

> A Western government that needs evidence of apparent progress in arms control for domestic political reasons, is fully capable of ignoring pertinent, military-analytical judgments suggesting that the agreement available is either of trivial or negative value to the national security. (3:76)

The important point is that the Soviets have access to a national instrument of power while the US does not. They derive their advantage from societal characteristics internal to our political structure. These characteristics hinder the US in an arms control arena, but yet these are

the same characteristics which many would claim make a democracy better than any other type of government in the world. Consequently, the job of any arms control negotiator becomes a monumental challenge.

Often in the process of arms control, negotiators do not have a sufficient understanding of the impact new, sophisticated, technological developments have on national security. On the other hand, well-versed technocrats do not have the skills necessary to be considered worthy negotiators. When one does not fully understand what is being bargained for, there is a reasonable chance that more damage than good will come of any arms control encounter. (3:76)

Because of the complexity of the issues involved, negotiators have a tendency to focus on those issues which are more easily agreed upon and verified, but of less importance for national security. An issue which has a large impact on respective national securities will naturally be more difficult to agree upon.

There has also been a tendency in past arms control talks for negotiators to fight for equality in an area. But equality is not necessarily what is needed or desired. For example, Gray points out that it would be foolish for the US to

negotiate for equality in certain space-related military capabilities "because of the asymmetry in space dependence of the two superpowers... [The US] may require superiority in active DSAT (or ASAT) capability." (3:77)

In conclusion, the Strategic Defense Initiative represents perhaps the greatest opportunity strategic planners have faced in the history of the nation. It has the potential to offer greatly improved security to future citizens, provided we have the wisdom and perseverance to follow through with our "technological virtuousity". The combination of ill Soviet intentions and unfortunate susceptible societal structure points very convincingly towards retaining SDI during the arms control negotiations. This country must recognize the Soviet Union for what it is, and what it is trying to accomplish.

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SOVIET REACTION TO STAR WARS

by

Cadet David D. Thompson

4 March 1985

SOVIET REACTION TO STAR WARS

In the volumes of material written concerning President Reagan's "Star Wars" proposal, writers often mention the "Soviet threat" or "Soviet response" to the proposal. Unfortunately, the discussion is usually limited to the Soviet reaction in one area, whether it be military, technical or political. In fact, the Soviet reaction to President Reagan's 23 March 1983, speech has been quick, decisive, and covers all fronts. In this paper I will examine, four areas of Soviet reaction to Star Wars. The areas will include military reaction, technical response, proposals on the diplomatic front, and statements issued. I hope to show the steps the Soviet Union is willing to take to defeat the Strategic Defense Initiative at any level.

While the Soviet Union has yet to make any military moves in direct response to SDI, they are continuing programs which have been around for years that would negate any advances in the SDI program. Additionally, they are working on strategic defense programs of their own. During the past decade, the Soviets have outspent us 20:1 in strategic defense. Soviet strategic offense and strategic defense expenditures are nearly equal. (1:18)

In response to the United States' present plans for a space-based ballistic missile defense, the Soviet Union would merely have to shift their nuclear arsenal toward cruise missiles, low-level bombers, and depressed trajectory ballistic missiles. (6) Currently, the Soviets are testing and deploying these systems.

The USSR possesses two operational systems which could be modified to enhance strategic defense. One is the Pushkino antiballistic missile radar site, which is a phased array radar that covers three-quarters of the western Soviet Union. Should the Soviets decide to break-out of the 1972 ABM treaty, the Pushkino radar site could be easily adapted to a missile, area-defense system (1:18) The other operational system is a modification of the SA-12 missile. "The Soviet Union has reportedly been testing its SA-12 missile against Soviet missiles with a reentry velocity roughly equivalent to US Pershing II missiles." (10:7) As the debate rages in the United States over whether or not to continue with the SDI program, the Soviet Union makes gains in its strategic defense capability.

In addition to the capabilities inherent in current Soviet systems, technical work continues in other areas of strategic defense. The most notable development is the Soviet

ASAT system. In the last fourteen years, the Soviets have conducted twenty ASAT tests. They used two different types of guidance systems: radar and infrared. Fourteen tests using the radar system have resulted in ten successes while the infrared system has yet to succeed. (4:25) Although the Soviet ASAT system has limited capability, it serves as a test bed for further research in the ASAT field.

The Soviets are reportedly making advances in the area of space-based lasers. US intelligence sources report that the Soviets could have an operational space-based laser with a range of a few thousand kilometers by the late 1990's. (2:250)

Countermeasures designed to reduce the effectiveness of a ballistic missile attack is another technical area to consider. Some of the countermeasures currently explored by US researchers include releasing chaff from the tips of warheads, using realistic decoys, deploying smoke screens by warheads to diffuse lasers, and spinning boosters to reduce laser effectiveness. (6) These options are also available to the Soviets as well, although we have no evidence that the Soviets are presently investigating these alternatives.

While the Soviets have been making strides in the military

and technical areas of strategic defense, diplomatic and propagandist programs aimed at the US strategic defense program began immediately following President Reagan's speech and are continuing today. The reason for this is twofold. First of all, US research into space defense would eliminate any advantages they might already have in the field, and secondly, " ... we have demonstrated our technological potential to render impotent ... Soviet intercontinental ballistic missiles, and Moscow has been shaken by it." (5) The Soviets fear an Apollo-inspired program resulting in ultimate security. In this light, the Soviet political campaigns are justified.

The Soviets have condemned SDI on the diplomatic front. They sent a team of scientists to Washington to meet with members of the Union of Concerned Scientists. Even though a news conference that was supposed to announce the results of the meeting was unexplainedly cancelled, both sides said that the meeting was productive and neither supported the use of weapons in space. (8:3)

The Soviet Union is hitting especially hard in the UN and at arms control talks. At the UN "... the USSR, in continually putting forth fresh peace-loving initiatives, calls for a total ban on the testing and deployment of any space-base

weapon for hitting objects ... in the atmosphere, or in space ..." (7) Before opening space weapons talks in Geneva last fall, the Soviets asked the United States to join them in declaring a moratorium on testing or deployment of space weapons. They wanted us to do this as a gesture of good faith. (3:1) When the United States refused to enter the talks with preconditions, the talks broke down and each side blamed the other for stalling in space weapons talks.

The announcement of President Reagan's space defense plan has brought forth from the Soviet Union one of the greatest propaganda assaults in recent years. The Soviets are using to their benefit every argument and division found in the US today. They especially like to join with members of US society in condemning the use of weapons in space. When scientists Carl Sagan and Richard Garvin sent a letter to party chairman Konstantin Chernenko supporting the non-militarization of space, Chernenko took the opportunity to reply and thank them for their peace-loving concern. Of course he also took the opportunity to condemn the Reagan administration and asked concerned Americans, like Sagan and Garvin, to rise up and defeat the Star Wars program. (11)

The Soviets see the US as:

> Desiring to spread its arms race to space. The Pentagon is pushing ahead with research into creating a series of antimissile systems, including orbiting stations with laser and particle beam weapons. (7:5)

The Soviets discourage the United States in its attempt to develop strategic defense weapons. The Soviets called the recent success in the Army's homing overlay experiment "a step toward the militarization of outer space." (9:2) Militarization of space is an area the Soviet Union categorically denies participating in.

There is no doubt that the Soviet Union wants the Strategic Defense Initiative to fall by the wayside. By preparing militarily and technically to avoid or win a battle in outer space, the Soviets are hedging against the United States in the event SDI continues. The USSR is quick to point out that their love of peace and refusal to use space for military purposes makes SDI a despicable act.

The Soviets would like to see SDI die.

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TIME CONSTRAINTS ON RELEASE AUTHORITY

or

CAN THE MAN IN THE LOOP GOVERN RELEASE?

C2C Lawrence A. Cooper

4 March 1985

TIME CONSTRAINTS ON RELEASE AUTHORITY

Command, control, and communications for an anti-ballistic missile (ABM) system pose as much a problem for SDI as do the limitations of today's technology. The limitations and problems will dictate the extent and effectiveness of SDI technology and must be examined, if not solved, before the impact on the deployment can be properly evaluated.

To effectively defend the United States and its allies, an ABM system must be able to quickly assess and react to a nuclear launch. The timely activation of an ABM system depends on how it is controlled. To be consistent with public opinion and US policy, the ABM system must have a human to activate weapon release. The nature of ICBM and ABM systems requires an attack be assessed and weapon release authorized in minutes if not seconds. There doesn't seem to be enough time for a decision to be made to release weapons and still have an effective boost phase defense.

To discuss the solution to the time criticial problem, three assumptions are made: first, the ABM system can adequately track missiles during all phases of flight. Secondly, immediate release is necessary only for a massive preemptive attack. The system can easily handle a small attack, by

waiting for confirmation of the threat, and destroying the missiles in later phases of flight. And third, a nuclear attack has a unique signature distinguishing it from normal space launches and natural phenomenon on Earth. ICBM launches are excepted to come from specific areas and silos that the US can locate prior to hostilities.

My position is that an effective ABM system must automatically react to any perceived threat. The boost phase intercept layer must automatically release weapons to have the time to acquire, track, and intercept the launched ICBMs. The other layers of defense can be placed on standby alert. A "watch officer", either airborne or based on a space battle station, is the "man in the loop". He will have the authority to either withhold release and override the system, or let the system continue to full alert.

A system requiring human intervention will be too slow to react. It takes a good deal of time to assess the situation, notify command personnel, decide if the situation warrants release, receive authority for release, and confirm the release order. It also takes time for the ABM system to lock on, track, and intercept the threats. ICBMs have delivery times of approximately twenty to thirty minutes. This necessitates rapid decisions if an ABM system is to be

fully effective; an effective system must destroy the warheads and boosters as quickly as possible. There doesn't seem to be enough time to wait for release authority from the National Command Authorities (NCA).

> The boost phase offers the biggest payoff with high visibility, value, and vulnerability. The missiles are easily spotted and tracked: and a strike in this stage delivers the maximum return in number of RVs negated. (2:2-7)

As strategists point out, maximum ABM effectiveness occurs during boost phase. For every ICBM intercepted in the boost phase up to ten reentry vehicles and perhaps hundreds of decoys are destroyed. However, the boost phase typically lasts only 150-300 seconds. Consequently, each and every delay reduces the available time for intercept in the boost phase. Each second of delay reduces the effectiveness of the boost phase intercept layer and decreases the effectiveness of other layer in the system by a greater amount.

An effective ABM system must encounter boosters early in the boost phase. An early encounter requires an automatic system reacting immediately to a crisis. However, the American public remains unwilling to trust a silicon chip. Therefore, a responsible human must have control over the system in case of any malfunction or accident. The "man in the

loop" for the present US ICBM Attack Warning and Assessment System demonstrates the need for a human to detect malfunctions and make the timely decisions that could prevent the accidental deployment of US forces. (9:53) Obviously a balance must occur between these two extremes.

The practical problems of attack and response arise from the conflict between the demands of peace and war. (7:38) Offensive and defensive forces must be deployed to deter war; but, measures must be taken against the accidental or unauthorized use of those forces (termed negative control). If hostilities were to break out, it then becomes important to ensure that these forces be used (termed positive control). (7:38)

Positive and negative control conflict with each other. They share an inverse relationship: the more positive control one has, the less negative control and vice versa. Insuring against accidental employment of force makes it almost impossible for the timely commitment of those forces.

In the US, positive control is ensured through procedures requiring two or more people to launch nuclear weapons. It is impossible for any one person to launch the weapons and improbable that the necessary combination can be assembled

without proper authority (7:38). Negative control is ensured by dispersing posts from which launch orders are given.

Any ABM System must have a balance of positive and negative control that ensures against accidental use while allowing for a timely response to an attack. The only precedent that the US has is the release procedures for our nuclear arsenal. An ABM system should not necessarily follow the same positive and negative control as the United States' nuclear forces.

Consider the nature of the high energy laser and kinetic energy weapons that will most likely compose the boost-phase layer defense. Laser beam power dissipates in proportion to the square of the distance traveled by the beam. Consequently, if the beam were to stray into populated areas, it will be harmless. Kinetic-energy projectiles will burn up in the atmosphere like meteors before impact. These weapons cannot be called weapons of mass destruction: they are designed to destroy missiles, not people.

Allowing the boost phase to automatically release weapons while the rest of the system enters different levels of alert, gives time to the decision makers to assess the

situation and respond to an attack. The "man in the loop" will have withhold authority over the system. A nuclear attack would activate the system, release the boost-phase weapons, notify the NCA, and place the rest of the system on alert. The "man in the loop" determines the extent of the attack. If the attack is obviously a nuclear strike, the system is allowed to continue with its order of battle. If the nature of the launch is uncertain and its size can be handled by the other layers of defense, the "man in the loop" withholds release until the launch can be confirmed or until he receives release authority from the NCA. The post-boost and mid-course phase continue to track and maintain readiness to intercept the attack if release is given at a later time.

If the National Command Authorities became incapacitated, a general officer can authorize release of nuclear weapons. Similarly a general officer acting as a "watch officer" would constantly monitor the ABM system. He or she would have the authority to withhold release of weapons or, by inaction, allow the system to self-activate. Should a malfunction or mistake occur, the watch officer would take action to prevent the destruction of a routine space launch or the attack of nonexistent targets.

Assume a system is deployed that requires manual release of weapons. Accidental activation of the system is almost entirely eliminated. Confirmation measures or constant supervision of the system would reduce the chances of a malfunction activating the system. The manual release mode will eliminate danger to routine space launches, but in the case of a preemptive nuclear strike the system manager would have to notify the NCA and wait for a decision to release weapons.

Most models of ABM systems predict sharp drops in effectiveness if release of the system is delayed 100 seconds or more. (1:5) The effectiveness depends not only on the system deployed, but also on the level and design of the attack. A massive launch would saturate an ABM system, but a launch of small, discrete waves could probably be handled without much loss of effectiveness despite release delay.

Major Lawrence Baker of the Joint Analysis Division conducted a fairly simple study that illustrates the loss of effectiveness associated with release authority delay. He found the most rapid loss in effectiveness occurs during the boost phase even with a freely transferable system: a defensive system whose initial layers continue to track and destroy weapons that have already passed through the layer.

Overall system effectiveness is reduced if system activation occurs after boost phase. For an attack by MIRVs equipped with decoys, waiting for a decision to activate would burden the system with even more targets to discriminate, track, and intercept. Consequently, effectiveness of the system would drop by an even larger factor.

Assume an automated ABM system is deployed. By programming the system to recognize the unique signature of multiple ICBM launches, it would automatically release and begin acquisition, tracking, and interception of the missiles. The monitoring "watch officer" would issue withhold authority if it seemed there might not be an authentic threat. Accidental destruction of satellite launches would be eliminated by this policy while the effectiveness of the ABM system would be preserved. Should the launch of only a few ICBMs occur, withhold authority could be given, and the missiles could still be intercepted by the other layers of defense. Note that legitimate launches of space vehicles will not occur in large numbers. Multiple launches are highly characteristic of an ICBM attack, but withold authority could be exercised for small threats that later defensive layers can handle.

An effective ABM system depends on its timely release of

weapons. Any delay increases the chances of an ICBM making it through the boost phase where tracking is easy and interception has the highest payoff. Release authority control should not duplicate the release authority necessary for using nuclear arms. The weapons in the boost phase layer are not weapons of mass destruction and could be released automatically without posing danger to populated areas on Earth.

Automatic release of boost phase ABM weapons is necessary to make the ABM system effective. Time is of the essence if ICBMs are to be intercepted. Any release delay causes a great reduction in the effectiveness of an ABM system. Withhold control provided by a "watch officer" would allow for timely decisions and actions. Immediate release of the system would provide maximum effectiveness. Routine space launches would not be endangered because 1) single launches would not be mistaken for multiple ICBM launches, and 2) the "man in the loop" can withhold release if a malfunction or mistake does occur. An ABM system can wait and assess the threat of a small number of simultaneous launches because post boost and mid-course intercept layers can track the missiles and intercept them if the "watch officer" or the NCA determines them to be hostile.

The time constraints imposed on release authority by the short reaction times must be resolved simultaneously with the technological problems of developing and deploying an ABM system. Without a sound policy for activation of the ABM system, the system's effectiveness is compromised and its value reduced. Automatic release and withhold authority allow for the timely and effective employment of ABM systems while maintaining responsible control. I recommend implementation of my release authority policy since it solves the problems associated with release delay and provides safeguards against system malfunctions and mistakes.

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SDI SENSORS

by

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4 March 1985

SDI SENSORS

"Star Wars", SDI, BMD - they're all the same thing with the same objective: to develop an active defense against intercontinental ballistic missiles (ICBMs). Scientists spend time thinking of ways to destroy the warheads before they impact the target. There is however, one factor which needs to be investigated. This necessary but often overlooked part of antiballistic missile defense is Surveillance, Acquisition, Tracking, and Kill Assessment (SATKA). SATKA requires adequate sensors. My paper will focus on sensors since they are an imporant part of a defense system. I will explore the present and future sensor capabilities and the associated problems.

There are four phases in ICBM flight. The boost phase occurs from launch to engine burnout. Post-boost begins at burnout and lasts until reentry vehicle (RV) deployment. From RV deployment to reentry is the midcourse phase. And finally from reentry to impact is the terminal phase. The SATKA sensors must be able to follow the missile or RV from launch through all four phases of flight or until it is destroyed. This capability is known as "birth-to-death" tracking. Tracking an RV is no longer necessary when the RV is non-functional, therefore, the sensor must be able to

determine when the warhead has been destroyed. This state may result from either a hard kill, physical destruction of the warhead, or from a soft kill, rendering the warhead firing mechanism inoperative.[1] Kill assessment is necessary in allocating weapons to avoid wasting additional resources on the dead RVs. Discrimination between RVs and decoys is also necessary for weapon allocation. Decoys come in various sizes and shapes and are made to duplicate characteristics of an RV. These dummy warheads range from balloons to radar reflectors, and there may be tens or hundreds for each actual warhead. With a limited number of defensive weapons, the ABM system cannot afford to waste its resources against dummy warheads. Consequently, sensors must be able to discriminate between the decoy and the RV. Of course if the enemy can destroy or neutralize the sensors, the rest of the defense is blind and worthless. Therefore, the sensors must be survivable.

Command, control, and communications (C^3) are just as important as the sensor, for without C^3 the sensors are of limited use and would be unable to perform their function in a timely manner. Failure to receive sensor information quickly denies the defense system adequate reaction time.

Associated with sensor development are a myriad of problems.

Detecting a missile in the boost phase is not difficult because of the booster's strong infrared (IR) signature. Once the engines shutdown however, the booster rapidly cools and the IR signal is no longer as prominent.[2]

There are several physical problems the sensors must overcome. The earth produces its own IR signature which clutters or interfers with the sensor. Clouds, weather, and the atmosphere can block or distort infrared, laser, and radar sensors depending on the frequency used. Ocean glint, the sun's reflection on the ocean, can obscure launch sites.[3]

Other problems involve target size and ranges. An RV is very small and not reflective. The size of the RV coupled with the need for accurate discrimination at ranges of anywhere from hundreds of kilometers to geosynchronous distances points to major problems. The problems become even greater when decoys are deployed to deliberately fool the sensors. There are problems of coverage, survivability, and cost. Because of submarine launched ballistic missiles (SLBMs), coverage must be extended to ocean areas as well as ground-based launch sites. Survivability is a necessity because of antisatellite weapons and countermeasures. Additionally, the high cost of the sensors must be included in the list of problems.

These are some of the major problems faced by SDI sensors. Presently there is some ability to overcome these problems and meet the requirements for SATKA sensors. One present day sensor contains IR scanning devices mounted in a Schmidt telescope assembly. The sensors are used to scan the Earth but they have many drawbacks. They cannot see through clouds; they are affected by ocean glint; they cannot accurately track a RV during midcourse because of high clutter returns; and signal processing limitations and ground links increase vulnerability.[4] These sensors are costly: each of the 2000 channels costs 5000 dollars apiece.[5] Inability to quickly replenish these sensors and the fluctuating shuttle launch schedule decreases the overall survivability of the system.[6] Other sensors are nuclear detectors such as the Vela satellites. Vela is found in 100,000 km by 115,000 km orbits, which enhances its survivability. Nuclear explosion detection satellites in low orbits contain gamma ray and neutron detectors as well as Geiger counters.[7] Unfortunately, warning of an attack from these systems would occur only after the first impact.

New sensors as well as improvements in present ones are forecast for the future. IR cryogenic cooling advances allow the detection not only of long infrared wavelengths, but also short IR wavelengths as well. This means that IR

can be used to track targets through midcourse. An example is the developing Space Tracking and Surveillances System (STSS) which uses mosaic IR sensors to look at the horizon. As a staring array of sensors, the device can track RVs that have cooled to room temperature without interference from Earth clutter. Since it is a staring sensor instead of a scanning one, response time is reduced.[8] Another concept explored is space-based radar. At the present time, the only limiting factor on radar sensors is size and power.[9] Imaging technologies under investigation use radar and lasers for discriminating RVs from decoys. The drawback is that imaging systems are effective at limited ranges and are not good for broad area searches.[10] If developed, though, they could help in kill assessment by detecting a tumbling or breaking up reentry vehicle.[11] Laser radars would scan with rapidly moving lasers to produce radar type results. But unforfunately power and distance limit the effectiveness of the sensor. Finally, low energy particle beams can be used for discrimination. When the particle beam hits the uranium in a warhead causing radioactive decay, the decay can be detected and the RV identified.[12] The particle beam sensor however, would not be effective for broad area searches.

The optimal sensors for future missile defense will possibly be a cryogenically-cooled, low IR sensor and a laser imaging

sensor, jointly mounted on one satellite. The IR sensor would accomplish broad area search, while the laser sensor would closely examine the IR results. Using the proper frequency and sensor coordination, "birth-to-death" tracking, kill assessment, and discrimination criteria will be met. Linking the sensors directly to weapons and hardening communications will make the sensors more survivable. Costs must be kept reasonable during the advances in technology.

Sensors are the eyes of missile defense. Without them our weapons are useless. Certain requirements or capabilities are needed for SATKA such as post-boost and midcourse tracking. With these needs come several problems. Although we have some ability to solve a subset of these problems, the future holds the promise of better sensors, especially in the IR and laser technologies.

FOOTNOTES

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SDI: THE VIEW FROM EUROPE

by

Cadet Nancy G.Galley

7 March 1985

SDI: THE VIEW FROM EUROPE

With the advent of President Reagan's Strategic Defense Initiative several new strategic questions are raised. Not among the least of these questions is the future of Europe as our strategic partner. European leaders express various levels of enthusiasm toward SDI. Each leader has valid points about the President's proposal and all views must be considered as significant inputs to the Strategic Defense Initiative program. This paper will provide a brief survey of European thinking on SDI and examine different sides of the argument as well as the actors.

First I want to examine the various statements made by European policy makers. At this time, the leaders of France and West Germany are unenthusiastic about SDI, while Margaret Thatcher, Prime Minister of Britain, stressed in a recent address to a joint session of Congress that she firmly supports SDI. [1,2] NATO Parliamentarians meeting in Brussels voted that President Reagan be urged to use his new electoral mandate not to promote his "star wars" but to negotiate a superpower ban on space weapons. Other leader's reactions have been polite but negative. NATO defense ministers meeting in Turkey in April wasted no time in letting Defense Secretary Caspar Weinberger know that they were

skeptical.[3] West Germany's Defense Minister Manfred Worner publicly declared that the President's program "would destabilize" the balance of power.[4] Dutch Defense Minister Jacob De Ruiter said the plan heightened the possibility of an arms race in space.[5]

At the September conference of the International Institute for Strategic Studies, American enthusiasts failed to convince the Europeans of the virtues of the concept.[6] French Foreign Minister Claude Cheysson recently compared the US SDI with a Maginot Line mentality, implying that the US could no longer be relied on to fulfill its obligations to other nations.[7] West German officials are concerned because, just as the pacifist movement in Germany was running out of steam, the SDI debate gave it new life.[8] The SDI proposal also leaves European governments baffled after the recent, hotly-contested deployment of Pershing missiles, missiles supposedly rendered obsolete by a ballistic missile defense system.

The next area I wish to examine is specific strategic objections put forward by the European community. The first argument brought forth by the Europeans is that they feel the SDI is incompatible with arms limitations talks and prevents a return to detente.[9] The period of detente

during the 1970's was a modern day golden age for Europe. The European community would be happy to return to that era. Another argument is that SDI is a "reckless and expensive chimera", a threat to British and French independent nuclear arsenals. [10] Any effective super power missile defense would reduce the deterrence of war in Europe by rendering British and French missiles, and American Euromissiles an invalid deterrent. [11] Note that when the small British and French missile forces are rendered obsolete, any chance of a world role for these powers vanishes. [12] "A hoax, an expensive hoax", is the opinion of King's College, Professor of War Studies, Lawrence Fredman, an acknowledged expert in strategic studies and avowed non-pacifist. [13] He goes on to say this opinion is the consensus of European as well as American specialists. [14] He states that "Star Wars" will make Europe more vulnerable to conventional war, because of its dependence on the threat of nuclear retaliation in detering any attack by superior Soviet-bloc conventional forces. [15]

However, the biggest fear among Europeans is that the SDI will "decouple" the United States and Western Europe and create a two class system of defense. [16] The superpowers would be protected from each other's intercontinental ballistic missiles; but because of theater nuclear weapons,

Europe and Japan would be left to defend themselves against Soviet aggression. Basically Europe will be undefended after the US retreats into Fortress America. [17] A further point to make is that a decoupled Europe may go neutralist and drift away from the West, with West Germany leading the way to "reunite" a divided Germany. [18]

Another point the European community is concerned about is the United States will develop a false sense of security since no such defense system can be perfect. [19] Further, once each superpower has its defensive "bubble", they are free to "slug it out" conventionally using Europe as their battlefield. [20] A final concern is that the American system would protect Western Europe too well, removing its independence, and making it a resentful satellite of the US. [21]

Finally, I am going to examine the thoughts of two Americans on the European's view of this issue. One is a politician, the other an expert strategic analysis. First, the politician, Senator William Proxmire, suggests there are three possible European courses of action if we do deploy a strategic defense system. One, NATO may go into its own defense business after the US retreats to Fortress America, and the European peace movement would then be able to force the dissolution of the remnants of NATO. Second, Britain and

France may scramble to increase their nuclear arsenals, scrapping any hope for intermediate-range nuclear talks. The third possibility is that Europe and Japan may seek their own accommodation with the Soviet Union, thus realizing an important Soviet goal, neutralized Europe and Japan. 22

The strategic analyst, Dr. David Yost, a National Endowment for the Humanities/International Affairs of the Council on Foreign Relations, sees four European concerns about the President's SDI proposal.[23] First, with the sole exception of Margaret Thatcher, no allied leaders were informed of the President's impending announcement of the SDI; Margaret Thatcher points out there was no consultation with our European allies.[24] Second, Europeans resent insinuations that existing NATO strategy is immoral as an unconstructive stimulus to the nuclear pacifist movement and of no assistance in their efforts to defend NATO strategy.[25] Third, Europeans were startled by the ambitious breadth of the proposal and felt it was technologically naive. Fourth, Europeans are unsure why the President chose to present such an underdeveloped policy. They feel it may be because the President wishes to avoid a bureaucratic death for his proposal.[26]

In retrospect, this paper has merely been a presentation of various opinions on the effect of the SDI on our European allies, no attempt has been made at an analysis of these conflicting views. However, this is the next logical step in the examination of the impact of SDI on our allies and this analysis is as vitally important to feasibility studies of SDI as the study of weapons systems.

FOOTNOTES

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21. Proxmire, William, p. 19.

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THE CONTROL OF SPACE AND DETERRENCE

by

Cadet Michael T. Healy

4 March 1985

THE CONTROL OF SPACE AND DETERRENCE

President Reagan's 23 March 1983 speech outlined the need for this country to explore the technological feasibility of strategic defense. His speech and the research program that followed, concentrated on long-range objectives. However, there are segments of a comprehensive strategic defense that can increase US national security in the near-term: the development of anti-satellite weapons, investigating measures to insure our own satellite survivability, and developing a comprehensive space tracking and surveillance system. It is my purpose to assess how these segments will enhance US national security. By national security I mean deterrence.

ASAT and satellite survivability systems are an integral part of the President's Strategic Defense Initiative and are a necessary ingredient to any comprehensive strategic defense architecture. Militarily, ASATs and satellite survivability combine to allow for the control of space, which in turn allows a country to perform whatever missions it deems necessary in space. For missions such as early warning, attack assessment, military communications, navigation, or ballistic missile defense (to name just a few), the control of space is a necessary prerequisite.

In order to determine what the control of space in the near-term will do for us, we must look to the present predicament in which we find our present military strategy. Since the 1960's, we have used the strategy of mutually assured destruction to deter the Soviet Union from launching an attack against us. According to Henry Kissinger, this theory suffered a major drawback, "...the Soviets did not believe it."[1] So, while we were building weapons to assure mutual suicide in the event of war, the Soviets were building forces for traditional military missions capable of destroying the military forces of the United States. The Soviet Union is now capable of destroying our military before it can "assure destruction". What we have done is develop a military strategy without credibility. Our strategy has no military utility.

The long-term solution to our military strategy problem is to develop a new and credible strategy. In the near-term however, we must eliminate the credibility of the Soviet strategy in order to insure our national security and deterrent. The ability to control space will allow us to deny the Soviets a viable military strategy by increasing their war-planning uncertainties beyond a tolerable level; they will be denied the ability to plan for a successful nuclear war.

To answer how the US will gain control of space, I will look at four ways in which both the Soviet Union and the United States use military space assets.[2] If the United States could deny the Soviets the use of space in wartime for surveillance and reconnaissance; attack assessment and warning; command, control and communications (C^3); and navigation, and insure our own use of space for these missions, we could effectively deny the Soviets of a plausible plan of military victory.

First, the Soviets rely heavily on their space assets for the mission of surveillance and reconnaissance, especially for the negation of our naval superiority. They use ocean-targeting satellites to direct their forces against our naval assets and may have the capability to perform real-time targeting with these systems. Without these systems in wartime, the Soviets would not be assured of effectively negating our naval forces, especially when we would be free to use space for the enhancement of fleet defense.

Another mission that the Soviet Union relies on for successful strategic military operations is attack warning and assessment. Without the ability to perform this mission the Soviets would not know the success of their attacks. Without the knowledge of success or failure, uncertainty is

greatly increases and their willingness to attack greatly decreases.

The third area in which the Soviets could be denied a viable military mission is in command, control, and communications (C^3) from space. An effective US ASAT would place the Soviets in the predicament of knowing that shortly after the initiation of hostilities they would lose their most effective means of controlling their forces. This also increases uncertainty and reduces the likelihood of hostilities.

The fourth area of reliance is providing navigational information to military forces. Without this information the Soviets would be denied the opportunity to improve their warhead accuracies with mid-course corrections from space assets. Less accurate warheads means less chance for military victory and thus less incentive to attack.

To increase the uncertainty of success for the Soviet military warplanner is to decrease his incentive to attack.[3] The bottom line is that ASAT's and satellite survivability will give the United States the ability to control space. That increases the uncertainties of the Soviet war plans, which in turn increases our deterrence.

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SDI: ALLIED VIEW

by

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4 March 1985

SDI: ALLIED VIEW

Since President Reagan announced the Strategic Defense Initiative, or "Star Wars" program, the media focused on the domestic reception or rejection of the program. The American people were concerned with how the program will affect the economy in terms of the growing deficit and how the system, if deployed, will affect the present stability in the world. Not until recently has attention focused on the reaction of our NATO allies to SDI. They, as much as anyone, are affected by the possible shift from an offensive to a defensive strategy. Realizing that the support of our allies is almost as important to SDI as is domestic support, the Reagan administration is pushing SDI to the leaders of NATO countries in order to gain approval. While the reaction has been favorable to this point, most of our allies still hold reservations, fears, and questions. This paper will examine potential reactions from our allies as the program continues to develop.

As one would expect, the proposal for such a drastic shift in strategy arouses many concerns of our allies. The present administration places significant emphasis on the collective security of Europe. One of the more important, if not the greatest fear of our allies in Europe, is the unilateral

development of a defense system by the US which could lead to a "Fortress America" or abandonment of Europe.[1] In a recent speech, West Germany's Chancellor Helmut Kohl gave qualified support for SDI. He said he favored the current research program. He also stated, however, that West Germany expected any decision to deploy SDI should be based on NATO's agreement on the matter. These words are an excellent example of the widespread European belief that SDI could reduce the United States's interest in the defense of Europe, building a "decoupling" effect on the NATO alliance.[2]

Another fear held by our allies in Europe is the Soviet response to a deployment of a defense system. The Soviets will deploy a defensive system of their own. As a result, the small, independent nuclear arsenals of Great Britain and France would become useless. This would reduce both of these countries capability to act in their own interests.[3] While the French defense minister, Charles Hernu, says that SDI will cause a more accelerated offensive arms race, but some think he fears a Soviet defense system built in response to SDI will make his country's forces obsolete.[4] France has recently committed to building up nuclear forces at the expense of their conventional forces. The British, likewise, have always strived to maintain an independent

nuclear force, especially in recent years with their decision to replace the antiquated Polaris SLBM system with the Trident.[5]

Another fear that arises in Europe in response to a Soviet defense system is that a conventional war in Europe would surely follow. With an effective defense system deployed by both the US and the Soviet Union, the Soviets might feel less inhibited to launch a conventional attack with their superior forces. This is precisely what the Europeans fear: a war between the superpowers which the Soviets would most surely win and which would probably result in the devastation of Europe. This is why the Europeans speak of deterrence, or avoiding open hostility. Europe grows nervous when the US speaks of defense.[6]

European leaders also express somewhat lesser concerns. Chancellor Kohl of West Germany refuses to give full support to SDI because of the upcoming arms control talks in Geneva this month. The Soviets could be tempted to dispose of all of their SS-20 missiles aimed at Western Europe in exchange for the withdrawal of European based US missiles and the cancellation of SDI. If this were to occur, Chancellor Kohl would not want to be known as the leader who took this opportunity away in favor of an unproven defensive system.[7]

Prime Minister Margaret Thatcher of Great Britain also gave qualified support to SDI during her recent trip to the US. She said she favored the research program but not actual testing and deployment. According to close aides of Prime Minister Thatcher, she still harbors serious doubts about the scientific feasibility and the strategic logic of SDI.[8] She is concerned about the "decoupling" effect of Europe with the US, and possible violations of the 1972 ABM treaty.

Despite these concerns by our NATO allies, Europe's cautious support for SDI tells the Reagan administration that the program is popular - when it is properly explained.[10] As originally designed, SDI would protect, in graduated steps: first US forces, second industry and transportation, and third the entire US population. At a recent NATO conference on defense issues, US Assistant Defense Secretary Richard Perle emphasized that SDI would be designed to intercept Soviet SS-20 missiles that are aimed at Western Europe.[11] In 1984, the US spent more money on defenses against bombers and cruise missiles than on defenses against intercontinental ballistic missiles.[12] This is obviously a reassuring fact that will help to lessen Europe's concerns. To sway European opinion toward SDI the US should invite its European allies to help with the research. [13] There is significant technological work to be done and a great deal of

money to be made.[14] Naturally, Europe wants its share of the money, especially in light of the troubled economies of Europe.

Presently, the Reagan administration is winning the debate in Europe regarding SDI. Due to the efforts of President Reagan, Caspar Weinberger, and George Schultz, the economic and scientific myths surrounding SDI, have almost been eliminated.[15] Yet no one really knows what the European reaction will be when and if the US deploys this defensive system. Support up to this time has been on the SDI research program. One European reaction could be a move closer to the Soviet bloc in what has been called the "Finlandization" of Europe. A move toward the East would be done largely out of fear of the destabilizing effect that SDI would have. Obviously the US would not like to see this happen, therefore, we will have to address European fears, consult with them on all decisions made, an reassure them that SDI will prove beneficial not only for the US but for all of NATO.

Another European reaction would be to work with the US to extend the "umbrella" over Europe.[16] And finally, Europe may react by building a defensive, star wars system of its own as proposed by French leader Francois Mitterand, a supporter of SDI since its inception.[17]

FOOTNOTES

1. Strategic Defense Initiative Working Group, A Military in Space -- A Time for Strategic Defense?. (USAFA), p. 20.

2. "Europe is Reluctant to Reach for the Stars, "The Economist, 16 February 1985, p. 45.

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SDI: EUROPEAN THOUGHTS

by

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4 March 1985

SDI: EUROPEAN THOUGHTS

The North Atlantic Assembly, an organization which represents the parliamentary bodies of NATO, rejected the proposal to endorse the US Strategic Defense Initiative program. Both the scientific and technical committee and the military committee of the Assembly rejected SDI for reasons ranging from insufficient information to a fear of escalating the arms race.[1] This stands as yet another setback for US hopes of obtaining public support for SDI.[2] Why the lack of support in Europe for President Reagan's SDI program? In order to give due respect to the importance of the NATO alliance, it is worthwhile to examine more closely the pros and cons behind European thought on SDI. The logical place to start is with an examination of what the Europeans don't like about SDI, the validity of those beliefs, and answers to those concerns.

The list of European fears concerning SDI resemble a tree. New opinions and ideas about the defense system only add new branches and leaves of concern for European thinkers. One of the more pressing issues at this time is the arms control talks in Geneva, which resumed after a year's break. The present political climate in Europe is one that places great

weight on the outcome of the talks. Public sentiment grew against the US in Europe in the interim. Europeans wanted the US to pullout its missiles and opposed further basing in Europe. Quite simply, the Europeans want arms reductions; and if a choice has to be made between arms reductions and a strategic defense system for the US, SDI will lose. Furthermore, the opinion is that there can be either arms control talks or SDI, but not both. The opinion is based on the idea that the Soviets will not reduce their own forces or slow nuclear production while the US is trying to develop a comprehensive antimissile system.[3] Europeans are also concerned that SDI will break the 1972 Antiballistic Missile Treaty which stands as the only functioning arms control treaty still in effect. Consequently, SDI has implications for any future arms control negotiations since the treaty is the only model of nuclear arms cooperation.

Beyond the topic of treaty negotiations lies the issue of what will occur if the US does in fact reach the deployment stage with SDI. It is likely that any European backing that presently exists will disappear when deployment is considered.[4] So where will US interests reside? Phrases such as "Fortress America" and the "Maginot Line mentality" are used to describe the possible decoupling of the US from Europe. Europe could be decoupled from the US since the US

would not be as inclined or perhaps, not even able, to counterstrike against an equal Soviet defense system.[5] A situation could exist where Europe is left to defend itself.

Even if the US does not choose to decouple itself from Europe, there are other issues on European minds. We can consider three senarios. First, if only the US has a defense system the country could become freewilling and bold in its foreign policy approach since the fear of any negative consequences would be greatly reduce.[6] This could endanger European security. Secondly, if both the US and USSR had a system, the European situation could become grave. The US and USSR would be protected. Nuclear arms including the limited deterrence forces of the British and French would be considered obsolete or impotent.[7] Consequently, a switch in deterrence strategy would be necessary, whether desired or not. The switch in strategy would most likely be to a resurgence in conventional forces of which the Warsaw Pact has the greater majority. A situation could arise where the US would provide the technology while the Europeans would provide the bulk of the manpower for the fighting, probably on European soil.[8] The third senario gives Europe and the superpowers a defense system. If Europe had a defense system, their political problems would seemingly be cured, but the question of economic feasibility must now be considered.

Would the Europeans undertake such an expensive venture? I doubt it, for even minor improvements on the present Patriot missiles for tactical ballistic missile defense are not welcomed by European politicians.[9]

Are the SDI issues insurmountable from the European viewpoint? No, not if western nations cooperate and plan to share the technological benefits from SDI research.

The Soviet Union continues research on defensive systems regardless of US intentions. Current Soviet rhetoric however, would indicate they are neither willing nor able to compete with the US in developing a strategic defensive system.[11] The US wants other nations to back its ideas for a defense system. In addition, the US does not want to eliminate SDI to insure success of the arms control talks.[12] Retaining SDI would force the Soviets to deal with the US and its SDI program at the arms control talks.[13]

SDI is a research program and does not violate the ABM treaty. If the US decides to deploy, the ABM treaty will have to be renegotiated with both the Soviets and our European allies.[14]

An American defense system capable of defending both the US

and Europe is not technically nor economically feasible. However, NATO could probably develop a ground-based system capable of protecting Europe at a much lower cost. Their system would be technically less complicated and orders of magnitude cheaper than the US system. Europe would only be concerned in defending against Soviet short range missiles, missiles that are easier to track, and are aimed at a more centralized area than those aimed at the US.[15] The defense system could be accomplished by an improvement in the Patriot missile.[16] US systems could help defend against missiles in the boost and post-boost phase of their trajectory.[17]

The incorporation of a successful defensive system would neutralize the British and French deterrent forces. Conventional forces now become important. Suppose the Soviet Union were to hold Western Europe after a conventional attack. "The new US emphasis on emerging technologies and an attack on follow-on-forces are aimed at extending the conventional phase of flexible response and thus reducing reliance on nuclear weapons."[18] Since the US is one of the key players, it is appropriate for the sixteen members of NATO to give consideration to the desires of the US.

Marvin Stone, the editor of <u>US News</u> & <u>World Report</u> says,

"our friends want our protection but often seem unwilling to share the sacrifice". This sums up my feelings on European doubts in establishing a defensive system against short and intermediate range ballistic missiles.[19] A defense system would be expensive, but the consequences of not having one could prove to be unacceptably high.

Are our expenditures on SDI the most cost effective way to promote the goals of NATO? Europeans say no, but the expenditures represent a rational way of protecting our societies. Perhaps SDI will mean fewer tanks and other conventional forces for NATO, but its a risk that needs to be taken.

Finally, there is a European concern if SDI fails. Paraphrasing Professor Lawrence Freeman, "the results of SDI could be another source of aggravation in East-West and Alliance relations, diversion of resources from more useful projects, and the nurturing of illusions about some technical fix to the problem of vulnerability in the nuclear age."[20] He could be right, but if we don't move ahead with SDI, no one will ever know.

This essay briefly looked at some of the European arguments concerning SDI and discussed their validity in an attempt to

solve current differences of opinion among many NATO members. In light of current Soviet insistence on having the US do away with SDI, it becomes important that every nation understands our position and tries to arrive at a common ground. Prime Minister Margaret Thatcher expressed a favorable attitude toward SDI as a research program. Hopefully her feelings will spread through the rest of Europe and allow everyone the opportunity to see what the future can hold.[21]

FOOTNOTES

1. "Atlantic Assembly Refuses to Support U.S. Plan to Develop BMD System," Aviation Week and Space Technology, 19 November 1984, p. 26.

2. Atlantic, p. 26.

3. Christoph Bertram, "The Star Wars Debate-Reagan's Dream: A Vision That Impedes an Arms Truce?" Die Zeit, World Press Review, March 1985, p. 37.

4. "Europe is Reluctant to Reach for the Stars," The Economist, 16 February 1985, p. 45.

"A Patriot for Europe?" The Economist, 12 January 1985, p. 31.

5. "The Third Dimension: NATO in Space - NATO and the Strategic Defense Initiative" NATO's Sixteen Nations, November 1984, p. 18.

6. Europe, p. 45.

7. Macha Levinson, "Why Europe Fears SDI," International Defense Review, vol. 18, no. 2, 1985, p. 133.

8. Patriot, p. 31.

9. Atlantic, p. 26.

10. Levinson, p. 133.

11. Europe, p. 45.

12. "Now for the Hard Part," US News and World Report, 21 January 1985, pp. 31-32.

13. Europe, p. 45.

14. Patriot, p. 31.

15. Patriot, o. 31.

16. Patriot, p. 31.

17. Levinson, p. 13.

18. Marvin Stone, "Star Wars: Pie in the Sky?" US News and World Report, 25 February 1985, p. 82.

19. Third, p. 18.

20. "American and Britain-Fan Dance," The Economist, 23 February 1985, pp. 21-22.

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ORGANIZATIONAL CONSIDERATIONS

for the

STRATEGIC DEFENSE INITIATIVE

by

Cadet Keith A. Knudson

4 March 1985

ORGANIZATIONAL CONSIDERATIONS

On 23 March 1983, President Reagan introduced the nation to the Strategic Defense Initiative (SDI) and propelled the United States into a national debate concerning the impact and consequences of pursuing such a program. In the two years since then, technical, political, and moral issues have raised serious thought, attention, and questions but few answers. Possibly the most popular area of debate has been whether the military-industrial complex can meet the needs of the research program. Debates involving George Keyworth, President Reagan's science advisor, and the Union of Concerned Scientists provided fuel for editorial pages and headlines for newspapers across the nation. As a result, the average citizen knows enough to hypothesize on complex technical issues such as lasers and maneuverable satellites, and on other issues involving political ramifications. President Reagan did not simply introduce a need for new weapon systems, but, in fact, detailed a completely new national policy towards nuclear strategy. The new strategy favors assured survival over the long-lived strategy of mutually assured destruction. My purposes in this paper is to introduce and provoke further thought on the organizational problems we face in the military in light of the uncertainties inherent in such a venture.

SDI, unfortunately, represents a paradigm of uncertainty, creating distinct problems in organization. The uncertainty becomes a major consideration in determining whether to develop a new organizational structure or use an existing one, one which will grow, change, and expand with SDI developments.

The US military tends towards parochialism which is criticized by the Joint Chiefs of Staff. The major commands of the Air Force, for example, jealously protect their interests by seeking to expand their control, especially in operational areas. The Air Force Systems Command, which performs research, development, and acquisition functions for the Air Force, has slowly entered into operations by acquiring operational control over a majority of Department of Defense satellites.[1] The tendency for an organization to expand control accelerates once serious questions are raised as to who will control the SDI program.

Incorporating the SDI program into an existing organizational structure is one option which deserves careful consideration. Any plan to incorporate a defense system into an already existing structure would surely involve the Strategic Air Command (SAC). SAC presently controls the Air Force's existing strategic offensive forces. This would

lead to a systematic approach in implementing strategic defense. Our defense operations therefore would be tainted by the concepts of strategic offense. The centralization of control required in SAC, due to the requirements of offensive nuclear weapons, would possibly hinder the development and deployment of a strategic defensive system. The execution of a defense system, by its very nature, needs to be decentralized.[2] Decentralized execution creates distinct requirements for command, control, and communications which demand greater reactive capabilities than would a corresponding offensive system. Because of the requirement for reactive capabilities of a command, control, and communication system, the Aerospace Defense Command (ADCOM) would become a participant in a battle for control over the strategic defense program. ADCOM presently controls two primary space operation centers: NORAD and the Space Defense Operations Center (SPADOC). Consequently, ADCOM would seem the right choice in any transition of strategic nuclear and space policy. There is perhaps more flexibility for growth in ADCOM as the strategic defense posture changes. Yet, because of the uncertainty of SDI's future, there is still the problem of an existing organization tainting the future with the past.

SDI is presently a research program. There is no direction

on developing any particular weapon systems nor on how they are to be deployed. If SDI were absorbed into an existing organization, a doctrinal shift would be required, but serious questions as to the specific organization's structure would still need to be answered. The complexity of implementing and operating a strategic defense system such as SDI, represents the biggest challenge the military has ever faced. The battle for command and control of the system would not be resolved until questions pertaining to release authority and types of weapons are answered. It is difficult to develop a coherent, operational policy without knowing the organizational structure. Consequently an interesting "Catch 22" develops.

As I previously mentioned, its critical to know the organization you propose to organize. Because SDI will change our nuclear strategy, it is critical to have a coherent agency orchestrating developments. A new command would attempt to do so. Ideally, the new command would grow with the program through the research, development, acquisition, and deployment phases. Unfortunately, its naive to think a new command would be formed this early in the SDI program. Nonetheless, the ground is fertile for studying the possiblility of a new command. The SDIO is somewhat of a unique structural entity, but in reality its closer to a mutant

organization which controls appropriations and manpower.

The recently formed Space Command may be the closest answer to the organization needed to house the SDI for now, and an integrated strategic defense system later. Space Command consolidates functions required for a coherent strategic defense program. The command's organizational structure is defined yet flexible enough to the changes in SDI's uncertain future.

As I pointed out, there are a variety of organizational factors which need to be considered as the SDI develops and transitions into operation. It is important for the military planner to consider the uncertainties facing the structure of a future strategic defense system. The organizational requirements cannot be met by piecing together developments as they occur. I intended to provoke thought on the uncertainties in the structure of the organization and explain how they affect the final product. Further study is required to find possible courses of action on the organization of SDI.

FOOTNOTES

1. Daniel O. Graham, USA (Ret), _High Frontier: A New National Strategy_ (Washington D.C.: High Frontier Inc., 1982, p. 57.

2. SDI Working Group, _The Military in Space--A Time For Strategic Defense?_ (U.S.A.F. Academy), pp. 29-30.

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A MATTER OF TIME:

A STUDY OF THE RELEASE AUTHORITY QUESTIONS RELATING TO SDI

by

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4 March 1985

A MATTER OF TIME:

The Strategic Defense Initiative is a program to investigate the feasibility of defending the United States against a ballistic missile attack. The deployment of large numbers of ballistic missiles by potential enemies poses challenging problems for our nation's strategic planners. A war, involving the use of ICBM's, would reduce reaction times to only minutes. Therefore, any proposed BMD system must take into account very short reaction times. The goal of this paper is to discuss the problems associated with the time constraints for a BMD system, to review system effectiveness as a function of time, and to investigate the level at which SDI weapons should be controlled. I then will state my assessment of the situation and a proposed solution.

The flight of an ICBM lasts anywhere between twenty and forty minutes and can be divided into four phases. The first phase includes the ascent of the missile through the atmosphere. The missile's rocket engines burn brightly and generate unambiguous infrared signatures that can be read clearly and easily. (1:108) In the second or post boost phase of flight, the bus separates from the main engines. After separation, the bus deploys the multiple reentry vehicles, and penetration aids. In the third or mid-course

phase, the warheads and penetration aids travel through space on ballistic trajectories several hundred miles above the Earth's surface. In the terminal phase the warheads reenter the Earth's atmosphere.

According to General Abrahamson, the boost phase of a ballistic missile provides the best opportunity for interception for several reasons. (1:108) First, neither the penetration aids nor the individual warheads are deployed and thus the defense can target truly lucrative targets. (1:108) Once the post-boost phase is complete, the warheads and decoys are deployed. The task of tracking and targeting becomes much more difficult. A ten-fold increase in tracking capability would be required if each missile deployed ten warheads, and a hundred fold increase would be required if ten decoys were deployed for each warhead. Consequently, a relatively small attack, on the order of one hundred missiles, could require tracking approximately 10,000 objects in the midcourse phase. Keeping track of all the objects, directing weapons against them, and providing effective kill assessment becomes an enormous task. Achieving a 90% effectiveness although seemingly very good, would in fact be misleading since part of the defense resources would be used against decoys. Thus 90% effectiveness would represent much less than 90% destruction of enemy warheads.

On the other hand, missiles in the boost phase can be easily distinguished from decoys and do not overload the tracking system since all warheads and penetration aids are not yet deployed. Large Soviet ICBM's and SLBM's burn relatively slowly. For example an SS-18, will burn for about five minutes. (1:108) In response to SDI, the Soviets will attempt to develop a fast burn missile, but there is no evidence that the burn time can be reduced to prohibit intercept.

To have an effective overall strategic defense its important to intercept the ballistic missile in the boost phase of its flight. To optimize the effectiveness of a boost phase weapon, a totally automated system would have to be deployed which would fire on warning of an attack. Firing early would insure intercepting missiles as soon as possible after launch. The United States however, will not deploy a system that is totally automated. A man will be placed in the loop to decide, based on the available data, whether to use the weapons. This provokes an interesting question: How will system effectiveness degrade as a function of delay in weapon release authority?

This question was posed to the Research Branch of the Office of the Joint Chiefs of Staff, Joint Analysis Directorate.

Their results are based on several scenarios and several different types of SDI systems.

This study confirms the importance of a boost phase intercept. There is a dramatic drop in effectiveness as release authority is delayed. If no action is taken at the end of the boost phase there is a dramatic drop in overall system effectiveness due to the release of multiple warheads and decoys. Since the post-boost and midcourse phases lasts for ten to twenty minutes, a delay in the release of weapons during this period will not significantly affect the overall effectiveness of the system.

Freely transferable intercept systems were also analyzed. A freely transferable system allows weapons primarily designated for use in one phase to be used in any other phase. As a result more systems are available for use in the post-boost and midcourse phases. A delay in release authority in the boost phase would leave the boost phase weapons systems available for use in the other phases.

This discussion indicates that it is critical weapons be released as soon as possible after launch detection to maintain an effective system.

Knowing that time is critical in defending against a nuclear attack, who should have authority for releasing the defensive weapons? Some say the President, since he is responsible for the release of offensive strategic weapons. I think that Presidential authority for release is unnecessary for a number of reasons. First of all, an SDI system would not involve the use of nuclear weapons nor bring destruction to the Soviet Union in case of an accidental activation. Directed energy weapons would attenuate to non-destructive levels before reaching the ground. Consequently, I feel that a lower level commander, should be responsible for weapons release authority. CINC NORAD would seem a logical choice. He would be one of the first to receive warning of the attack and would have the ability to analyze the situation more quickly than anyone else. He would, therefore be given the authority for the defense of the continental US.

The goal of this paper was to point out some of the problems associated with time constraints in a ballistic missile defense system. I have shown that an immediate response and an effective boost phase intercept are critical for an effective SDI system. I discussed the question concerning system degradation as a function of release time, and the question of who should have release authority for SDI weapons. This paper is only an overview of a very

complicated yet important issue.

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THE SYSTEM'S THREAT: A SOVIET ASAT

by

Cadet David N. Larson

4 March 1985

THE SYSTEMS THREAT: A SOVIET ASAT

An operational space-based ballistic missile defense (BMD) system would have to deal with Soviet countermeasures. The countermeasures would range from jamming to destroying the entire system and could be space-based, such as "hunter-killer" satellites, or ground-based such as ground based lasers. According to The Soviet Year in Space, the Soviets have two laser facilities at the Sary Shugan Test Range. "American and British high altitude satellites have already...suffered temporary anomalies...within the vicinity of Sary Shugan which could have been caused by low-power laser radiation." (4:37) The Soviets also have an electronic warfare capability. The Soviet Year in Space indicates that the capability may have already been used against an American satellite. (4:37) The greatest threat today is, however, the Soviet co-orbital antisatellite. Soviet Conquest from Space states that the Soviets are testing an unmanned satellite with the ability to inspect or destroy other satellites. (2:121) Ru'anan and Pfaltzgraff cite that since 1968 the Soviets have tested twenty "hunter-killer" satellites and sixteen were considered to be successful. (5:71) Consequently, from the examples above, the Soviet offensive capability in space is real. Any defense we develop against the ballistic missiles will have to deal

with the threat of a Soviet antisatellite (ASAT). The Soviet co-orbital ASAT is probably the greatest threat to a BMD system today.

Ru'anan and Pfaltzgraff say that the range of the Soviet co-orbital ASAT ranges from 160-1,500 Km above the surface of the earth. (5:71) But according to Aviation Week and Space Technology the Soviets are developing a Saturn V class launcher which could easily reach geosynchronous orbit and beyond. (7:110) Colonel Earnest Seborg of The Space Warning and Surveillance Division, states that although the Soviet ASAT of today threatens low altitude satellites, the heavy boost vehicle will threaten geosynchronous satellites by the end of the decade. (6:47) By the time we deploy a BMD system, the Soviet Union will have the capability to destroy it.

Some feel that we would know if a Soviet attack on our system is imminent because of increased space activity. Soviet Conquest in Space states that the Soviet ASAT has a storable propellant, and is simple, reliable, and durable. (2:121) This means the Soviets could launch space mines, keep them dormant, and then activate them to attack. Under these circumstances it's possible we wouldn't see an increase in Soviet space launches. Some also think that we would be

able to react to an attack. But the Soviet ASAT has a quick reaction time according to Ru'anan and Pfaltzgraff. The Soviets were able to close in on the target within 1 or 2 orbits during all tests. (5:71) If we assume a 1,500 Km orbit, the time of flight for two orbits would be greater than 3 hours. With thousands of objects in space it is unlikely that we would observe an ASAT if it only takes 3 hours to hit its target. A BMD system would likely be in a higher orbit taking an ASAT a longer time to reach it. Another problem arising is the possibility of Soviet, space-based, laser ASATs. Aviation Week and Space Technology expects the Soviets to launch a space-based laser ASAT in the near future. (7:10) Such a system could act quickly, even before we knew it had attacked.

The Soviets have a high-volume launch capability. Aviation Week and Space Technology says that the Soviets have shown they can launch many times a day. (8:70) This indicates the ability to perform quick-reaction launches. Ru'anan and Pfaltzgraff state that the Soviet ASAT is launched by the SS-9 booster/ICBM and can be readied for launch in less than 90 minutes. (5:71) Consequently, ASATs can be launched by the Soviets without much warning.

In response to the Soviet ASAT, Colonel Brown, the author of

Balance of Power in Outer Space, says the Soviet's ASAT system is too expensive to counter an entire system. He questions the utility of an ASAT attack. (1:4) The present Soviet ASAT maneuvers next to a target and explodes destroying itself and the target.

What is the US doing about the Soviet ASAT? Soviet Conquest from Space describes our past policy as retaliation with nuclear forces for damaging US satellites. (2:12) The same book also cites that the retaliation policy wasn't flexible or credible. (2:12) Consequently, the US is developing its own ASAT. According to Aviation Week and Space Technology, our ASAT will serve as a deterrent. (6:46-47) The US ASAT is ground-based and effective for low earth orbit.

On 18 June 1982 the Soviets launched an ASAT Cosmos 1379 to destroy Cosmos 1375 launched 12 days earlier. The test failed due to a warhead fusing malfunction. Within 6 hours of launching the interceptor, the Soviets also launched two ICBMs, two ABMs, one IRBM and an SLBM. These multiple launches demonstrated ASAT integration in the Soviet force structure. In addition, the Soviets launched a reconnaissance satellite and a navigation satellite simulating replacements of lost satellites in battle. This Soviet exercise is recorded in Aviation Week and Space Technology.

(7:110-111) This exercise demonstrates the Soviets preparedness to use their ASAT in a strategic attack, such as destroying an ABM system to ensure a successful first strike.

The ASAT is a threat to our BMD system. To be an adequate deterrent, BMD must be able to defend against the Soviet ASAT.

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TREATIES PERTAINING TO SDI

by

Cadet Steven Grupenhagen

4 March 1985

TREATIES PERTAINING TO SDI

On 23 March 1983 President Reagan made a historic speech asking the American people to use their technology to build a defensive system making nuclear weapons obsolete. The defense system is still in the research stages with many unanswered questions. This paper will focus on only one of the many questions: Will the President's SDI program abide by current U.S. treaty obligation? And if it doesn't, what should the United States do about it?

Two treaties could possibly affect the SDI program: the Anti-Ballistic Missile (ABM) Treaty of 1972 and the Outer Space Treaty of 1967. In this paper I will assume an SDI system most likely to be deployed, examine the two treaties to see which phrases apply to the President's program, and draw some conclusions on the treaties' future.

According to Brigadier General Rankine's briefing charts, "Air Force Participation in SDI," the BMD system will include directed energy weapons, kinetic energy weapons, and radar systems. The directed energy weapons will be space-based and attack missiles in the boost and post-boost phases. The kinetic energy weapons will be space and ground-based.

Article I of the ABM Treaty states "each party (shall) not deploy ABM systems for defense of its territory (except as allowed)." Since any SDI system is obviously a defensive anti-ballistic missile system, it seems a US system will violate the treaty. However, Article II specifically defines an ABM system. It defines an ABM system as having interceptor missiles, missiles launchers, and radars. The treaty states that these ABM systems can be deployed in only two areas (later reduced to one), and must be nonmobile and ground-based.

Since the treaty only refers to interceptor missiles, all other weapons including kinetic and directed energy are usable. The homing overlay experiment demonstrated that interceptor missiles as the most likely system to become operational. Without interceptor missiles, the construction of an SDI program may be delayed until other weapons are fully developed.

Limits on radar are also addressed by the ABM Treaty. The treaty specifically limits radars used in an ABM system to those ground-based radars around an ICBM field or the capital city. Without radar the surveillance and tracking will be impossible for an SDI program.

The US has three options concerning the ABM Treaty. First, we can build a system that meets the requirements of the treaty. This would be a poor choice considering the radar restrictions and the present lack of radar substitutes. Secondly, the United States can invoke Article XV and withdraw from the treaty. It is very hard to say whether this would be a good decision or not. It could be destabilizing. The third choice involves modifying an "agreed statement" by the Soviets and Americans allows for treaty changes. Unfortunately, this option is contrary to the current Reagan policy of not bargaining with SDI.

The Outer Space Treaty of 1967 can also affect the SDI program. The Outer Space Treaty was written to prevent the militarization of space. The one article that pertains to the SDI program is Article IV. Article IV states that no nuclear weapons or other weapons of mass destruction will be placed in orbit around the earth. The problem is in specifying a "weapon of mass destruction." This term can be strictly or loosely defined. Thus, it may or may not be applied to directed energy and kinetic energy weapons in space. Some argue that the treaty limits SDI weapons, but the treaty remains ambiguous on the issue.

The Outer Space Treaty is clear about nuclear weapons,

but it is unclear about the nuclear power needed for the weapons. Thus, if a laser were powered by a nuclear reactor, it could be argued that it did not violate the Outer Space Treaty.

I feel that the Outer Space Treaty will not affect the SDI program. The treaty is nearly twenty years old and has been violated many times especially concerning notification and disclosure of space launches. Even though the treaty is not strictly enforced, the Unites States ought not withdraw; rather, such terms as "weapons of mass destruction," and "nuclear weapons" need to be defined.

In summary, the President's SDI Program may be affected by the ABM Treaty and the Outer Space Treaty. The Outer Space Treaty will not have a significant impact on SDI since nuclear weapons will not be used. On the other hand, the ABM treaty may affect an SDI program by limiting interceptor missiles and radars. I encourage negotiation of parts of the treaty or risk destabilizing consequences. Once treaties are signed they are not usually given much attention, but our country has a moral obligation to abide by them.

IN FAVOR OF SELF-DEFENSE

by

Cadet Robert Eamon

4 March 1985

IN FAVOR OF SELF - DEFENSE

As citizens we are concerned with the defense of our country. Consequently, we should be concerned by the Soviet buildup of strategic, military systems. We need to realize that the strategic force modernization program has become necessary for strategic stability. Part of our strategic stability, involves defensive balance. However, a defensive balance does not exist between the USSR and the United States. In the next few pages, I will present a method of integrating defensive forces into US strategic systems in order to achieve balance and make nuclear war less likely.

In order to launch a retaliatory strike, our bombers and ICBMs must be able to survive a preemptive nuclear attack. An effective defense will help our strategic forces survive. Currently, however, our defensive forces are non-existent.

Former Secretary of Defense James R. Schlesinger, the author of US defense policy states, "...without effective ABM defenses, air defenses are of limited value against potential aggressors armed primarily with strategic missiles." (4:1-13) Therefore, because of our deficient air defense, deterence is based on retaliation.

Patrick J. Friel's article, "U.S. Ballistic Missile Defense Technology: A Technical Overview" from Comparative Strategy, discusses four classes of ballistic missile defense (BMD) technology the US is or has been investigating: first is terminal defense; second, exoatmospheric defense; third, "simple" or "novel" defenses; and fourth, directed energy weapon defense. (1:324) Note that all the defenses are only in the research phase. Simply stated we have no defense against the ICBM. Friel states that the defensive systems cost much more compared to offensive systems. He also explains faults with each defensive system and concludes defense is useless. But, couldn't we gradually integrate these defensive systems into our strategic forces?

Rodney Jones and Steven Hildreth, authors of "Star Wars: Down to Earth or Gleam in the Sky", state that "a limited ballistic missile defense system...could be deployed now or in the near term with existing technologies ." (3:108) Gradual incorporation of defenses would increase the survivability of our offensive forces and our power of deterrence. The increase in defense, however, could possibly result in a continuing offensive arms race to nullify the defenses. We sould be "...risking parallel offensive and defensive arms race competition." (3:108) A defensive system, therefore, would be valuable if arms control agreements are negotiated

concurrently with defensive deployments. According to Jones and Hildreth though, defensive systems may be valuable even if there are no constraints on offensive weapons.

Terminal and midcourse interception of ICBMs is feasible. "Short-range interceptors capable of...attacking Soviet warheads as they reenter the atmosphere can probably be deployed in the 1980's." (6:166) Terminal defenses have many appealing qualities. First, they would not be subject to the vulnerabilities of a space-based system, and secondly, these defenses are based on conventional technologies, therefore, their cost is much lower and more predictable. (3:109)

With lower costs, and foreseeable results, Congress would be more likely to fund developing terminal defenses. Our technology could be given to our allies to provide extended deterrence. Terminal defense could aid our allies and promote arms control agreements with The Soviet Union.

In the article, "Stabilizing Star Wars", Alvin Weinberg and Jack Barkenbus explain a method of deploying defensive systems while at the same time reducing offensive arsenals:

> Here is a simplified example of how DPB (defense- protected build-down) might work. Assume that the US and

> the Soviet Union have achieved parity with 1,000 weapons each. A US BMD system capable of destroying 10 per cent of these warheads in an all-out Soviet attack would leave Moscow with only 900 deliverable weapons. This situation would permit Washington to dismantle 100 of its warheads and still maintain the offensive balance. If the Soviets followed suit by deploying a BMD systemthey believed would be twice as effective--which would have double the kill probability of its US counterpart--Moscow would have to reduce its nuclear arsenal to 800 warheads. These measures would leave each side with 720 deliverable warheads in each other's estimation... (6:167)

There are certainly some problems with this proposition, particularly in estimating the effectiveness of a BMD or proving the dismantling of missiles, but these problems can be worked out. A limited defense has added benefits. The defense system can be used for point defense against an accidental launch or even a small scale attack.

The Wienberg and Barkenbus proposal, though overly simplified, is very appealing and can be negotiated with the Soviet Union. This proposal could be used for implementing terminal defenses, our most technologically feasible program. As technology progresses we can move to negotiating space-based defense systems. The process of trying to negate the ICBM threat is excruciatingly slow, but it is possible in the long term. By increasing our defense, deterrence increases, making nuclear war less likely. The way to increase our defense is by slowly eliminating ICBMs as

effective weapons. As a result the offensive arms race will end.

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MUTUAL ASSURED SECURITY

STRATEGIC DEFENSE IMPLICATIONS - NATIONAL SECURITY OBJECTIVES STRATEGY AND MILITARY DOCTRINE

by

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1 May 1985

MUTUAL ASSURED SECURITY

For the past thirty years, the driving force behind the United States' defense posture has been mutual deterrence. The term "deterrence" implies that a potential aggressor's actions will be thwarted due to a fear of catastrophic nuclear destruction, while the term "mutual" implies that both sides impose the deterrent successfully upon each other. Hence, "mutual deterrence" equates to "mutually assured destruction", (MAD) a defense doctrine with which many are at least familiar.

Based on the carefully worded definition above, MAD is a brilliant doctrine, and given its requirements, can provide security to states having nuclear destructive capabilities. Many would argue, and justly so, that MAD has preserved the relative peace in the thirty years since its inception. However, it's apparent that MAD is deteriorating, and our continued reliance on it may threaten the survival of the nation.

The purpose of this paper will be: first, to discuss why MAD must be discarded as a guideline to weapons acquisition, targeting, and arms control; secondly, to assess a proposed

solution to our security dilemma -- the Strategic Defense Initiative and finally, to attempt to synthesize a new defense doctrine -- a doctrine based on mutually assured security, rather than destruction.

In order to understand MAD, a brief look at its origins is required. As nuclear weapons developed from their infancy in the late 1940's, the country was soon faced with a dilemma. The prevailing post-WWII mood in the country was towards demobilization, yet national security was a growing problem:

> President Eisenhower had committed himself to a policy of fiscal restraint. He wanted to cut the defense budget appreciably, and yet he had to do so without jeopardizing either America's territorial security or its worldwide commitments. In an effort to reconcile these contradictory desires, the President and his Secretary of State, John Foster Dulles, enunciated in the winter of 1953-54 a strategic doctrine that to an unprecedented degree based the country's security on a single weapon, the nuclear deterrent. In an address to the United Nations in December 1953, Eisenhower argued that since there was no defense against nuclear weapons (ie, thermonuclear or hyrdrogen bombs, which both countries were beginning to produce), war between the two "atomic colossi" would leave no victors and probably cause the demise of civilization. A month later, Dulles enunciated what came to be known as the doctrine of "massive retaliation." The United States, he declared, had decided to "depend primarily upon a great capacity to retaliate, instantly, by means and places of our choosing." The Eisenhower-Dulles formula represented a neat compromise between America's desires to reduce the defense budget and simultaneously to retair the capacity to respond to Soviet threats. The driving force, however, was not military but budgetary: behind "massive retaliation" (as well as its offspring,

> "mutual deterrence") lay fiscal imperatives. In the nuclear deterrent, the United States found the perfect resolution to the conflicting demands of domestic and foreign responsibilities. (8:136)

The doctrine of "massive retaliation" was doomed to a rapid course of deterioration when the Soviets exploded their first atomic bomb in 1949. The US was eventually forced to acknowledge that it could no longer act with impunity, but it could still maintain the deterrent of "assured destruction". As Soviet capabilities improved, and parity was reached, the doctrine became known as "mutual assured destruction." The concept, however, was driven by the same motivations that created massive retaliation, as Richard Pipes illustrates:

> This doctrine was worked out in great and sophisticated detail by a bevy of civilian experts employed by various government and private organizations. These physicists, chemists, mathematicians, economists, and political scientists came to the support of the government's fiscally driven imperatives with scientific demonstrations in favor of the nuclear deterrent. Current US strategy was thus born of a marriage between the scientist and the accountant. Weapons procurement was to be tested and decided by the same methods used to evaluate returns on investment in ordinary business enterprises. Mutual deterrence was taken for granted: the question of strategic posture reduced itself to the issue of which weapons systems would provide the United States with effective deterrence at the least expense. Under McNamara, the procurement of weapons, decided on the basis of cost effectiveness, came in effect to direct strategy, rather than the other way around, as had been the case through most of military history. (8:136-137)

The important point made here is that, when dealing in

national security matters, a sound strategy that provides true security should come first. The scientist and accountant should most effectively and efficiently implement the strategy once its foundation has been laid. This is not to imply that MAD has been devoid of any military merit. It is, however, logical to conclude primary considerations were misaligned when MAD was originally formulated.

As mentioned, a key term in the doctrine of mutually assured destruction is the word "mutual." Consequently, no discussion of MAD is complete without also understanding Soviet political ideologies. We must assume that ideologies drive, in part, Soviet actions in world affairs, since it is from these beliefs that the Soviet government derives its legitimacy to govern.

At the roots of contemporary Soviet ideology is Marxism. Karl Marx borrowed an analytical technique called the dialectic from a great German philosopher George Wilhelm Friedrich Hegel (1770-1831). The dialectic is a process whereby one takes an idea, a concept, or a solution to a problem, and opposes it with its counterpart. The concept itself is called a thesis while its counterpart is called the antithesis. The antithesis is derived from contradictions in the thesis. A "unity of opposites" is eventually

reached, and the result is a "synthesis" which is quite different from either the thesis or antithesis. (9:89) As the process continues, the synthesis becomes a new thesis, which begets its own antithesis.

Marx used the dialectic to derive what he felt were inevitable economic stages of societal evolution, with each stage representing a change for the better. The determinant for each thesis and antithesis is based on a division of the classes -- those who control the means of production and those who are controlled. A tension exists between the two classes, and Marx asserts that the resolution of the resulting conflict can only occur through revolution with the more numerous oppressed class eventually emerging victorious. For example, a revolution between slaves and slave owners brings about feudalism, creating "lords" and "serfs." Separation between classes diminishes as one "progresses" up the dialectic. This progress, from a Marxian point of view, is based on materialistic productivity. The highest form of government is communism, in which there are no classes, hence no class struggles. Government, in the absence of conflicting interests, ceases to serve a purpose, and vanishes. Without scarce resources, politics is meaningless, and society has evolved into a near-perfect utopia.

This revolution occurred at the turn of the century in the Soviet Union, and, according to Marxist theories, it would only be a matter of time before the revolution would take place world-wide, one sovereign state at a time. When the revolution failed to occur, Lenin, who used Marxism to legitimize the Soviet revolution, explained in his book, <u>Imperialism: The Highest Stage of Capitalism</u>, that capitalistic states delayed the revolution by exploiting and colonizing the third world. He argued that the access to the additional cheaper resources enabled imperialist nations to temporarily appease the working class and prevent unrest. (9:95)

Due to this imperialist exploitation, Lenin set up what was actually a socialist, not communist, government. The function of the Soviet Communist Party was to aid a proletariat class now defined as global, and to free those oppressed classes from further exploitation by facilitating "wars of national liberation" where and whenever possible.

This puts the United States in an interesting position from a Marxist/Leninist point of view. On an international scale, the United States represents the world bourgeois class, the exploiters, the oppressive imperialists; while the Communist Party of the Soviet Union sees itself as the

vanguard of the world's oppressed proletariat. By definition, as the antithesis of the bourgeois, the world proletariat must overthrow Western states, bring an end to capitalism, and move the world to its natural advanced state, communism. As mentioned, government, including the Soviet's, ceases to have a purpose once world communism is achieved. The conclusion is obvious and terrifying -- the Soviet government has no purpose, no legitimacy as a world power, unless it is actively and successfully destroying, imperialist sovereignties such as the United States. Consequently, any formal recognition of the imperialist's legitimacy, such as meaningful mutually beneficial arms control, serves to undermine The Communist Party's legitimacy.

As mentioned, the doctrine of mutual assured destruction must meet certain requirements by those who choose to use it. First, each must subscribe to the required vulnerability of its society to the other's nuclear forces. If one or the other could successfully defend themselves using active or passive means, then deterrence is no longer mutual, and MAD breaks down. The second major requirement for MAD involves the survivability of retaliatory forces. Both sides must be able to absorb a first strike and still be capable of inflicting unacceptable damage on the adversary, otherwise there is nothing to stop one side from starting a

nuclear war. Therefore, by subscribing to MAD, each side implicitly agrees to help the other to preserve its retaliatory credibility.

The United States has complied with the MAD doctrine requirements almost completely. We have no civil defense program to speak of, and no ABM systems whatsoever. The idea of societal vulnerability has never been a problem in the United States. The US has also placed a great deal of emphasis on survivable second-strike forces; but as American ICBM's have grown increasingly vulnerable since SALT I, deterrence relies almost entirely on relatively inaccurate SLBM's which are not likely to remain invulnerable much longer. The US attempted to "institutionalize" the requirements of MAD by signing the SALT I and ABM Treaty but was clearly not successful. The Soviets protect their society through an extensive civil defense program, maintain the only operating air defense or ABM system in the world, and more recently, perform research on defensive directed-energy weapons. By significantly degrading our ability to deter, these facts have increasingly rendered MAD less and less meaningful. Additionally, the Soviets have placed an emphasis on low-survivability, ground-based, highly-accurate, ICBM forces - first strike weapons. It appears, therefore, that the Soviets are not interested in

cooperating with fiscally-driven American defense philosophies.

The lack of Soviet cooperation should not be surprising, considering the mission that supposedly legitimizes the Soviet government's right to existence. MAD requires a certain strategic balance that results maintaining world "status quo": a status quo the US hoped for through the use of mutual deterrence. Since the Soviets see themselves as the antithesis of capitalism, they cannot agree to a strategy that maintains the status quo. MAD requires Soviet adherence for success. Because of Soviet ideology, however, MAD cannot fulfill its promise as a credible and mutually advantageous strategy. Consequently MAD is a unilaterally beneficial policy for the Soviets.

Not only has Soviet ideology prevented the United States from realizing its goals with MAD, but also Soviet military doctrine and force structure are contradictory to MADs requirements. The Soviets, unlike the Americans, retain a strong Clausewitzian influence upon their military doctrine. Clausewitz's idea that war is politics by other means, has convinced the Soviets that victory is possible anywhere along the political-military spectrum. Victory will go to the nation best prepared in terms of equipment, training,

and doctrine. Thus, Soviet doctrine is directed for the realization of victory, even at the level of nuclear war.

Richard Pipes cites five elements of Soviet military doctrine we find contradictory to the theory of MAD's minimum deterrence and strategy pursued by the United States. (8:142-145) First, the idea of preemption and surprise pervades Soviet thinking and explains why over 70 percent of the Soviet strategic nuclear force consists of land-based ICBM's. (10:30-32) Preemption and surprise is the result of Soviet desires to avoid early defeat in war, as they suffered in World War II at the hands of the Germans. A preemptive strike destroying the US nuclear force on the ground is an active defense.

The second element, the acquisition of counterforce capability, helps the Soviets carry out the destruction of US retaliatory forces through weapons, SS-18 and SS-19 ICBMs, with the accuracies and yields sufficient to destroy hardened silos. (10:26-30)

The massive Soviet ICBM buildup in the 1970's supports the third element of Soviet doctrine, quantitative superiority. Quantitative superiority, enables the Soviets to execute a preemptive, counter-force strike, yet still maintain

sufficient forces to gain political advantage in a post-strike confrontation with the United States. Paul Nitze has captured the seriousness of this situation:

> The threat of a second strike, which underpins the mutual-deterrence doctrine, may prove ineffectual. The side that has suffered the destruction of the bulk of its nuclear forces in a surprise first strike may find that it has so little of a deterrent left, and the enemy so much, that the cost of striking back in retaliation would be exposing its own cities to total destruction by the enemy's third strike. The result could be a paralysis of will, and capitulation, instead of a second strike. (7:141)

The fourth element, the Soviets emphasize is the concept of combined-arms operations. Through this element, the Soviets reject the Western notion that nuclear weapons have radically changed the nature of war. From the Soviet point of view, nuclear weapons are simply one more weapon on a broad spectrum of military tools. Accordingly, these weapons have the same mission: the destruction of the enemy's capability to resist. (2:19-20) The huge concentrations of troops in Eastern Europe and the Soviets' large, fully-capable Navy reflect beliefs that a nuclear war will require the complete spectrum of available weapons if victory is to be achieved. Combined-arms operations also ensures the entire war effort will not be crippled if one segment of the Soviet force is successfully countered.

The last, element of Soviet military doctrine, the pursuance of strategic defense, minimizes Soviet casualties to acceptable levels should their preemptive, counterforce strike miss any US retaliatory forces. Soviet ABM research, development, and deployment support the desire for a damage-limiting capability. (3:38)

All five elements of Soviet doctrine highlight methods of warfare directed at achieving victory, not at maintaining mutual assured destruction. These characteristics are detrimental to US national security since MAD is a mutual policy, requiring Soviet compliance for its effectiveness.

On March 23, 1983 the President set forth a proposed solution to the waning effectiveness of our present defense strategy. The President's Strategic Defense Initiative constitutes an alternative to MAD; one that drastically changes our view towards nuclear weapons and deterrence. The administration's position has been summarized in four sentences:

> During the next 10 years, the US objective is a radical reduction in the power of existing and planned nuclear arms, as well as the stabilization of the relationship between offensive and defensive nuclear arms, whether on earth or in space. We are even now looking forward to a period of transition to a more stable world, with greatly reduced levels of nuclear arms and an enhanced ability to deter war based upon an increased

> contribution of non-nuclear defenses against offensive nuclear arms. This period of transition could lead to the eventual elimination of all nuclear arms, both offensive and defensive. A world free of nuclear arms is an ultimate objective to which we, the Soviet Union, and all nations can agree. (7:1)

The administration feels its objectives with respect to SDI will unfold in three distinct phases. First, the United States wants to stabilize the relationship between the Soviet Union and itself through arms control agreements limiting the most destabilizing weapons (ie, large, MIRV'd, accurate ICBMs). The Strategic Defense Initiative research program is studying the technological feasibility of defensive measures against nuclear weapons. This phase seeks stabilization through arms control and simultaneously seeks a solution to the problem of MAD through research.

The decision whether to proceed with the development of strategic defense systems will be made at the end of the first phase. If the United States decides defensive systems are feasible, the second or transition phase would begin. The administration has outlined the criteria by which the defensive technologies will be judged. The criteria include survivability and cost effectivness. A defense system vulnerable to attack would decrease rather than increase stability. Additionally, a defense system must cost the US less to develop and deploy than it would the Soviets to

overwhelm it.

The administration has stated sharing technology for defensive systems is in the interest of both superpowers only if the US and the Soviets agreed to deep reductions in offensive forces. If the SDI research program is successful and the political hurdles of the transition phase are cleared, the ultimate phase would begin.

In the ultimate phase the threat of nuclear destruction is eliminated. Nuclear weapons will be reduced to near zero, and non-nuclear defensive systems will be widespread. The deployment of defensive systems will insure the futility of any undetected cheating. The administration calls this mutual assured security.

The national security objectives of the United States will not be drastically altered by a reorientation of American defense posture toward defensive measures. Strategic defense will not represent a change in goals, but rather a change in the method of achieving those goals. Lawrence J. Korb's article, "The Defense Policy of the United States," outlines four national security objectives. (4:57) First, the United States seeks to deter conventional and nuclear attacks by the Soviet Union on itself and its allies.

Second, the United States wishes to keep open sea and air lines of communication between itself and its trading partners around the world. Its third objective is to provide an international environment where democratic development may flourish (stability), human rights are observed, and access to markets is free. The last objective is to resolve conflicts favorable to US interests and with a minimum amount of losses. As stated, there is no significant change to national security objectives, but there are some marginal ramifications that would accompany any shift to strategic defense.

The first security objective provides the basis for strategic planning in the United States and is the objective any defensive system would need to fulfill. The threat of nuclear terrorism, however, would require modifying the objective. Nuclear terrorism can be a threat of attack from a country other than the Soviet Union, in order to gain a US concession, (strategic defense would eliminate this threat) or a threat from what has been referred to as a "suitcase bomb". (5:60) A "suitcase bomb" refers to smuggling nuclear devices into the US and placing the bomb close to targets. Detonation would occur when deemed appropriate by the attacker. Nuclear terrorism can not be executed on a large scale, but does remain a possibility. However, difficulties

in acquiring the necessary materials, in constructing the device, and in moving the weapon undetected around the country would make this type of terrorism nearly impossible. Those who criticize defensive strategies for not disabling such a threat should realize that short of closing US borders, no military strategy could meet the threat.

The second objective requires the United States to project conventional military power world-wide. Strategic defense will not directly enhance this objective. It will however, increase the conventional weapon importance by denying political utility of escalation to nuclear weapons. (1) Effective levels of conventional power are needed to deter Soviet aggression in Western Europe and to insure the United States will maintain its vital lines of communication.

The next objective, creating a free international environment, is one which a non-nuclear, defensive system could have an impact. The Reagan administration feels world-peace based on defenses, rather than the threat of retaliation, represents a more stable and less fearful peace. Peace and stability without fear is a favorable international environment.

The last objective outlined by Mr. Korb seems to contradict

the first objective in the context of MAD. Those who support MAD claim nuclear war is unwinnable (whether the Soviets believe it or not). Therefore, it is not in the interest of either country to devote resources to strategic defense. A defensive system will increase uncertainty in the outcome of nuclear war. Consequently, nuclear devastation is not consistent with the requirements of the fourth objective. Strategic defense reconciles the conflicting objectives. Strategic defense will deter nuclear war by eliminating the political utility of an attack, yet still provide a favorable outcome should deterrence fail. Sufficient levels of conventional military force will be required to favorably conclude conflicts at lower levels once nuclear weapons are eliminated.

Overall, national security objectives remain unchanged when shifting from offense to defense. In fact the change helps meet those objectives better.

As outlined above, the deterioration of MAD due to Soviet non-compliance has led to widespread concern over the efficiency of present US national security strategy. Presently under MAD, US strategy requires survivable retaliatory forces and vulnerable societies. Both have been compromised. (1) A shift to a defense dominate strategy would

require only the invulnerability of Western society. If met we will deny the Soviets political utility from the use of nuclear weapons. A defensive strategy can be effectively implemented unilaterally and not require Soviet compliance with the American concept of deterrence which does not reflect Soviet ideology and doctrine.

By denying the Soviets political gain from their nuclear offensive forces, they will more likely give them up in an arms control agreement. An example of this occurred in the ABM treaty in the early 1970's. Since ABMs were thought useless against ICBMs, the Soviets easily gave up ABMs. Critics of strategic defense claim the Soviets will attempt to build more offensive forces to counter US defensive weapons. However, the present US administration developed criteria for the strategic defense program which would preclude the Soviets from building more offensive forces. The defensive system must be survivable, to insure the viability of the defensive weapons themselves and marginally cost-effective to make it prohibitively expensive for the Soviets to overwhelm a defensive system cheaper to improve than it is to overload. Under these conditions the Soviets will turn to defensive systems and give up their offensive weapons to obsolescence.

Many critics have also charged that a defensive strategy makes Europe (NATO) vulnerable to Soviet conventional power in the absence of the American nuclear guarantee. (6:2) This situation is contrary to all four US national security objectives and means an end to NATO. The United States would respond in a number of ways to avoid this catastrophe. First, the United States must include NATO in any strategic defense architecture (to include defense against theater nuclear forces). Once the nuclear threat is eliminated the United States must ensure that its conventional commitments are sufficient to stop a Soviet attack long enough to allow superior American and European economic power to assure victory.

In the ultimate phase of a defensive strategy, the only avenue of interaction left open to the Soviets is non-violent diplomacy. With the reduction in the utility of nuclear weapons, the vigorous pursuit of arms control, and alliance solidarity, the United States can create a more stable peace.

If the US shifts its military posture toward defense, military doctrine will be affected. A defensive system must deny the Soviets the ability to escalate a conflict to nuclear war. If the United States can successfully

eliminate the possibility of nuclear war, it will be at a disadvantage given the current conventional force levels. This could have grave consequences for US national security if left unchecked. The United States will have to give up its fiscally driven notion of "more bang for the buck," to maintain world security while eliminating the threat of nuclear war. To meet national security objectives, conventional military doctrine must return to the principles of war. Therefore, we will need to change present US military doctrine.

The control of space must be included in the revision of US doctrine. (11:311) Space control is similar to sea control pursued by the Navy. Since defensive systems will rely heavily on space for effective operation, the United States must control space. Control includes denying space to the Soviets and insuring US space systems survivability. Consequently, the Air Force responded with the creation of the Unified Space Command.

Conventional sufficiency must be incorporated into US doctrine. Sufficiency does not require the United States match the Soviets in all categories of conventional weapons. It does means the United States must be prepared to stop Soviet conventional aggression long enough to allow NATO industrial

strength to react. A superior industrial base will insure the Atlantic Alliance will eventually prevail, if the industrial base is safe from attack, protected by the strategic defense system.

Traditional US doctrine of "firepower and mass", therefore, must be altered and stress "maneuver" and "economy of force". The Army's recent emphasis on maneuver and mobility, and the employment of smaller units, demonstrates the utility of this doctrine.

Changes in the way the United States thinks about and conducts warfare, could effectively deter war at both the nuclear and conventional levels. Military effectiveness and the political utility of the Soviets nuclear forces could be negated by a comprehensive strategic defense system. The Soviets costly, offensive-minded, conventional forces could be negated by relatively less-expensive, defensive-minded, US conventional forces. This could constitute an effective means to contain Soviet expansion.

When analyzing MAD and SDI, we looked at two concepts to deter nuclear war. First was minimum deterrence, the conceptual precedent of MAD, and second was the maintenance of a war-fighting capability. We determined minimum deterrence

does not represent a credible deterrent, especially in the face of Soviet non-compliance. Additionally, an effective war-fighting capability is too costly and results in an increase in the Soviet-American arms race, without an increase in security.

Both of these concepts rely on offensive capabilities. A shift to defense is a departure from both. If the United States wanted to deter the Soviets from launching a nuclear attack, it must deny them the political utility of the attack. If there were no utility in the initiation of a nuclear conflict, there would be no incentive for them, hence the name "denial theory".

The United States can eliminate the political utility of Soviet offensive nuclear weapons by eliminating the effectiveness of their weapons. As a result, defensive capabilities and denial theory come together. An effective defensive system prevents the Soviet Union from escalating to nuclear war. In addition, denial theory induces a favorable arms control environment, in which the United States could bargain from a position of strength without building the systems it is attempting to eliminate. Denial theory relies on weapons inherently less threatening and more stable than the present nuclear offensive forces. The weapons are less

threatening because they are designed to kill weapons, not destroy Soviet society.

Denial theory applies to both nuclear and conventional levels. Soviet nuclear offensive forces are ineffective with a comprehensive strategic defense. Additionally, Soviet conventional, offensive forces are ineffective because of US conventional sufficiency, which will stop Soviet forces long enough to allow superior NATO economic strength, protected by a strategic defense system, to overwhelm the enemy.

Therefore, the Soviets are forced to compete with the United States and Europe on our own terms and without violence. Consequently, we will demonstrate the superiority of the free-market, our economic systems, western values, and our political institutions world-wide without the interference of Soviet military power.

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BALLISTIC MISSILE DEFENSE:
THE PROBLEM OF SURVIVABILITY

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ABSTRACT

This paper investigates ways to enhance the survivability of a space-based ballistic missile defense system.

First, the paper developes system architecture for the basic assumptions of the system and its defensive requirements. The proposed system consists of three satellite types: Orbital Weapon Platforms (OWPS); Surveillance, Acquisition, Tracking, and Kill Assessment (SATKA) satellites; and Battle Management (BM) satellites. Discussed are the functions of these systems and their orbits.

Outlined next are potential threats against a BMD system. Generally, these threats are classified as directed energy threats, kinetic energy threats, and electronic attack. This section describes the destructive effects from these threats on our BMD system.

Thirdly, the paper discusses the different techniques employed to enhance the survivability of the BMD system. These countermeasures to threats are comprised of passive measures -- hardening, stealth, task distribution, and EHF communications; active measures -- decoying, maneuvering, self-defense, and shuttering; and other measures -- involving maintenance, redundancy, reconsitution of systems, and system security.

Finally, countermeasures are needed by the different system components are analyzed. Certain countermeasures are necessary for specific tasks, but not for others. Hardening, EHF communications, stealth, self-defense, maneuver, and task distribution are desirable to some degree on almost all systems without exception, however, certain altitudes will make some countermeasures ineffective. Specially dedicated defense satellites or on-board defensive systems will provide retaliatory capability against threats.

THE PROBLEM OF SURVIVABILITY

An important problem with implementing a Ballistic Missile Defense (BMD) is ensuring the system survive in the face of Soviet countermeasures. Before deploying or even developing a BMD system, one must first ascertain whether the system can survive electronic countermeasures, direct attacks, decoys, and deception.

This paper looks at the weaknesses and limitations of a BMD system's space components and describes how the Soviets could exploit these problems. We'll also examine future dilemmas o ensuring the survivability of the system as well as countering or minimizing the effects of countermeasures. The ground segment will not be discussed.

Our analysis of BMD system architecture shows a BMD system composed of three types of satellites: Orbital Weapon Platforms (OWPS); Surveillance, Acquisition, Tracking and Kill Assessment (SATKA) satellites, and Battle Management (BM) satellites. Due to the limitations of the space environment, in particular the Van Allen Radiation Belts, these satellites will be in either high or low earth orbits. The placement of these satellites will depend on their capabilities. Placement increases the problems associated with

survivability and may cause large increases in the number of satellites necessary to maintain an effective defense.

To best enhance survivability we determined we must place real-time critical battle management functions in low earth orbit to provide real time response to attacks on the BMD system. Some BM satellites must also be in high orbits to control the entire battle and apportion assets effectively.

Individual system countermeasures include hardening against laser and particle beam attacks, using electrical current-limiting devices on SATKA and BM systems, and employing Defense Satellites (DSATS) for mutual and point defense. To reduce the vulnerability of choke points, we require task distribution.

In this paper we make a number of assumptions. We assume we can fully deployed a BMD system twenty years from now, and we assume the state of technology flow will be the same in the future as it is today. Therefore the Soviets will eventually obtain the weapons systems we develop, and vice versa.

SYSTEM ARCHITECTURE

The three satellite types in a BMD space system are: 1) Orbital Weapons Platform Systems (OWPS), 2) Surveillance, Acquisition, Tracking and Kill Assessment (SATKA), and 3) Battle Management (BM). Dedicated constellations of these systems will fight the battle during the different phases of ICBM flight (boost, post-boost, mid-course, and terminal).

BMD satellites will be in low or high earth orbit. Medium orbits except for semi-synchronous (20,7000 km) are undesirable due to the Van Allen Radiation Belts. (3:8) The Van Allen Belts are filled with electrons and protons that have energies on the order of 1 Mev and exist at altitudes of approximately 1.5 to 6.0 earth radii. (6:96) These particles can degrade electronic systems on a satellite. Although the altitudes vary with solar activity, the inner proton belt's peak flux is located approximately 2,200 miles in altitude while the outer electron belt's peak flux is at an altitude of about 9,900 miles. (6:241) Even though the low density area between the two belts is relatively safe, it is best to avoid the Van Allen belts to preserve space system integrity.

Low orbits are below 2-2.5 earth radii while high orbits are

defined as those above 5 earth radii. Orbit selection will avoid high-energy, particle density areas. The advantages of low orbits are better resolution and tracking and a reduction in time of flight from orbit to interception. High orbits maintain the high ground, cover more area, and are harder to locate. It takes a long time to reach a high orbit and difficulty to identify satellites in the high orbit.

OWPS consists of various weapons systems such as lasers, particle beams, and kinetic energy weapons and will have its own internal acquisition, pointing and tracking systems for its weapons. Consequently, if SATKA and BM satellite functions are disrupted, OWPS can function autonomously. These weapon systems will be in low orbits to reduce time to interception, to penetrate further into the atmosphere, and to reduce the pointing and tracking error. OWPS will include Defense Satellites (DSATS) to protect communication, SATKA, and BM satellites in other orbits.

SATKA is composed of sensors that use optical, radar, infrared, and laser-imaging technologies. These satellites will be in both low and high earth orbit depending on their individual resolution capabilities. SATKA systems in low Earth orbit will function as acquisition, tracking, and kill

assessment spacecraft, while SATKA systems for surveillance and early warning will be in high orbits for initial warning and tracking data.

Normal data transmit time between low and high orbits (including processing time and multiple data transmissions between different systems) will be on the order of seconds, which could compromise the integrity of the BMD system. Therefore, for those systems in low earth orbits, BM systems will coexist on the SATKA satellite to minimize the time for transmittal of data from BM and SATKA satellites to OWPS. The mixture of systems reduces the number of satellites in low orbits and allow BM satellites close proximity to OWPS, for the timely commitment of DSATS.

Battle Management includes communication satellites and relies on computers to control the battle. Like most of today's communication satellites, the BM satellites will be in geosynchronous, semi-synchronous, or molniya orbits to cover larger areas with fewer satellites. Span of control dictates the need for only a few of these satellites with each controling a large segment of the BMD system. BM satellites are chokepoints and therefore lucrative targets. Destruction of any one satellite can severely impair the entire system by degrading system integrity.

The BM satellites which oversee the entire battle will be in high orbit, but dedicated BM systems will be in lower orbits to coordinate SATKA and OWPS which are fighting the primary battle. The higher orbit satellites' primary function is to coordinate the entire battle and to provide information transfer between the different phases. Additionally, these satellites will provide overall command and control of different subsystems and a ground link for human interface with the system.

THREATS TO A BMD SYSTEM

There are many threats against a BMD system. We will examine these threats from the attacker's viewpoint. Since our concern is how the weapons will affect BMD components, we divided the threats into four categories: directed energy, kinetic energy, electronic attack, and general weapons. The last category includes weapons not readily grouped with the first three categories.

Lasers and particle beams are directed energy weapons. Lasers types include chemical, excimer and x-ray. While the methods for generating the beams may differ, the effects of the beams are the same. Lasers strike with the speed of

light so the defender doesn't know he was attacked until after the laser beam strikes. Lasers are also effective in blinding sensors so objects cannot be acquired and tracked.

Another property of lasers is that they deposit their energy on the surface of the target. Thus a laser, destroys the outer covering of a satellite as well as the inner components. This destructive effect could be used against all three types of satellites in a BMD system.

There are problems with lasers worth discussing. The width of a laser beam increases in proportion to the distance travelled. This reduces the energy density of the beam. Additionally, pointing and tracking error increases with distance, so however small the error may be, when multiplied by ranges of hundreds of miles, the error becomes large enough to make it difficult to hit a target with accuracy. These problems increase the range limitations on laser weapons, therefore it is desirable to have the laser weapon as close to the target as possible. With powerful lasers it's possible to blind satellite sensors from the ground.

Particle beams are different from lasers since they deposit their energy inside a satellite by passing through the outer layers. The actual depth at which the energy is deposited

depends on the energy of the particles and density of the target. Particle beams are used to maximize the damage to a satellite since the energy will simply pass through any shielding. Particle beams have problems though. Besides being inherently unstable and hard to control, charged particle beams are affected by the Earth's magnetic field. On the other hand, neutral particle beams, though not affected by the magnetic field directly, collide with atmospheric molecules stripping electrons from the air and forming two charged beams which then spiral because of the Earth's magnetic field. Therefore, neutral particle beam weapons can only be used outside the atmosphere.

The different types of Kinetic Energy (KE) weapons are railguns, space mines, and guided missiles. We assume only conventional warheads will be used on KE weapons since nuclear warheads can cause considerable colateral damage by generating an electromagnetic pulse.

Railguns give the attacker the advantages of determining whether the satellite has been damaged since the targeted satellite fractures into many pieces. Railguns can be used effectively against all types of BMD satellites. The disadvantages of railguns are the requirement for ammunition and the time of flight to interception. When the ammunition is

expended the railgun is useless. Additionally, the railgun must be able to plot the target's trajectory so interception can be achieved. Smart projectiles that can home in on the target will compensate for inaccuracies in traking.

Space mines have several advantages. First, they can be prepositioned, that is, they can be placed in an orbit before the attack keeping the mine in proximity to a target or in a location to blend in with other space objects. At an appropriate time the space mine could do an orbital transfer burn to put it alongside the target. There would be no warning time for the defender to react.

If a space mine altered its orbit, it could be detected. The targeted satellite could then move out of the way, but this could cause the BMD system to lose effectiveness. Additionally, space mines could be salvaged fused to destroy someone or something tampering with it.

Space mines are effective in geosynchronous orbits since they could be easily disquised. If the mines were in other orbits, they might be more easily detected, since other orbits are reserved for specific satellite missions. Consequently, it would be hard to disguise the space mines purpose.

Space mines cannot be used as a quick response weapon since it takes time to position the mine. The mine can be tracked as it's positioned and possible targets identified ahead of time. With ample warning, the the mines can be intercepted or the targets could move out of effective range.

The guided missile is another intercept vehicle able to attack low altitude satellites. Guided missiles are easily deployed at ground sites where the missile can be hidden until needed. Additionally, missiles could be deployed on satellites and used at close ranges. Guided missiles will be most effective against the low orbiting OWPS.

The disadvantage of guided missiles is the time of flight. Since travel time is not instantaneous as it is in a directed energy weapon, the missle can be tracked giving the target time to react.

There are many forms of electronic attack. A few that will be discussed include microwaves destruction, spoofing, jamming, and EMP. All forms of electronic attack are subversive. They could be used without the defender realizing the enemy is responsible. Thus, electronic attack can be used in a prewar scenario to degrade a defender's BMD system.

Microwaves affect a satellite in two ways. First, in the front door attack, microwaves at the same reception frequencies of communications and sensors could destroy electrical components. Communication and sensor systems boost the frequency gain so even faint signals are detected. A high-energy, highly amplified microwave beam sent at the same reception frequency could destroy a satellite's electronic systems and vital components. This front door approach is most effective against battle management and SATKA satellites which depend on their sensors and communication links. The other approach is the backdoor attack. Any satellite bombarded with enough microwave energy will leak energy through the seams and through electronic leads on the outside of the spacecraft. The satellite's internal systems will become vulnerable to electrical overload. This backdoor attack is effective against all types of BMD satellites. Problems with microwave attacks include the need for large amounts of power and knowledge of the target's receiving frequency.

Spoofing occurs when the attacker sends commands to the defender's satellite taking over or prohibiting control. Spoofing can be accomplished many ways. For instance, an attacker can command a satellite to turn itself off, or change its orbit or orientation. Spoofing is possible

against all satellites in a BMD system.

Jamming interfers with satellite instructions from the ground or from other satellites. Overloading spacecraft sensors can also be considered jamming. Jamming is a powerful technique since it denies a defender command, control, and communications with his system. It is however, hard to tell whether the attacker has effectively interfered with the system.

EMP refers to the electromagnetic pulse caused by nuclear detonations. Nuclear warheads detonated in space generate a pulse that causes electrical overloading and system burnout. The problem with this threat however, is calateral damage.

Other threats not previously discussed consist of orbital denial and the Soviet space plane. The threat of the space plane lies in its versitality. With orbital support such as space stations, the space plane can easily change inclination threaten all our low earth orbit satellites. Missiles or directed energy weapons can be mounted on the space plane and used in close promisity to a BMD satellite ensuring a kill. Additionally, the space plane can monitor our satellites and reveal their functions and weaknesses.

Releasing debris in an orbit denies a spacecraft the use of the orbit. Small particles even as small as sand, can be deadly because of the impact velocities. Depositing huge quantities of ball bearings or detonating shrapnel bombs in orbit can scatter enough debris to make an orbit unusable for our systems. The disadvantage of orbial denial is the technique denies the orbit to everyone.

COUNTERING THE THREATS

Countermeasures are categorized as passive, active, and other types. Passive measure include hardening, stealth, task distribution, and the use of EHF communications. Active measures employ maneuvering, self-defense, mutual defense, shuttering, and decoys. Some of the other measures for increasing the survivability of a BMD system are maintenance, redundant systems, reconsitution, and system security. Since satellites are inherently soft targets, these measures cannot ensure against system degradation, but can reduce degradation and minimize the destruction of the system.

Hardening provides the satellite with armor or reflective and ablative coatings to withstand, absorb or reflect the

destructive energy deposited on the satellite. In particular, a satellites' solar panels are extremely susceptible to damage and should either be replaced by internal power sources such as nuclear power or employ retractable panels for defense.

Hardening against EMP involves the use of fiber optic links, and special shielding such as a faraday cage around the critical systems of the satellite. Hardening against microwave radiation involves the use of current limiting circuits, such as surge protectors, so radiation on receiving antennas is reduced to tolerable levels. EMP hardening helps SATKA and BM satellites to continue to operate despite a high energy radiation environment.

Task distribution ensures other elements of the BMD system duplicate the systems functions and tasks. This allows other satellites to assume vital tasks if one satellite needed to shut down because of attack or system failure. For example, the sensors of OWPS could perform the function of SATKA if the SATKA system were degraded. Additionally, each BM satellite sould be able to manage by itself a segment of the BMD system. The BM satellites will alternate as the system manager so an attack on critical nodes will not destroy the entire BM system.

Using EHF communications reduces the likelihood of jamming. Additionally, EHF communications increases the probability of communicating in an EMP environment associated with a nuclear exchange.

Decoys are balloons or dummy satellites with similar radar crossections and infrared signatures as the satellite itself. Decoys can be deployed with the satellite or ejected by the satellite when threatened. Decoying confuses the aggressor's attack systems as to the real target forcing him to spread his resources thinly and thus increase the chances of satellite survivability.

A BM satellite can order a spacecraft under attack to move. Additionally, a satellite could maneuver on its own initiative if attacked. Once a spacecraft senses an attack by a missile, a space mine, or some other ASAT-type weapon, the target satellite can perform an orbital maneuver to move out of attack range. For maneuver to be useful, we need a real-time space tracking network to discern space mine or missile approaches and to plot their trajectories. A maneuver during a space mine's orbit transfer can increase the range separation between the target and the space mine and reduce the likelihood of damage. Maneuver is not as useful against directed energy attacks since the satellite

has no time to react.

Self-defense enables the satellite to counterattack once the attacker is identified. Therefore offensive weapons need to be placed on BM and SATKA systems. The OWPS satellites not engaged in battle will target and try to eliminate threats to the BMD components involved in the battle. Using OWPS to eliminate destructive threats is mutual defense. Mutual defense also includes having dedicated DSATS for the protection of different constellations.

Shuttering sensors on a satellite under attack prevents the loss of the system. The sensors will remain shuttered until the threat is eliminated by defensive systems or until the satellite can maneuver away from danger. Shuttering is especially useful should the Soviets use lasers in an attempt to blind the satellite.

Maintenance enhances the survivability and usefulness of the BMD system. To keep as much of the system operating properly, we need to provide on-orbit maintenance including repaires and services. Quick maintenance turn-around requires all BMD systems use modularized satellite components so repair can be done quickly and economically. For example if an attitude control module burned-out or

malfunctioned, an astronaut could maneuver alongside the satellite and simply replace the module. Modularization can improve the system by replacing the modules with new, improved technology as it becomes available.

System redundancy relies on space-based, prepositioned satellites to replace damaged or malfunctioning satellites as needed. Redundancy within the satellite is also required for high reliability.

Launching satellites as others are destroyed is reconsitution of the force. Reconstitution requires a quick launch capability. Although replacements will not be useful in a brief battle, the advantage lies in the event of a protracted war consisting of multiple attacks.

Security involves coding transmissions to reduce usefulness of intercepted transmissions and to prevent spoofing.

RECOMMENDATIONS AND CONCLUSIONS

A BMD system will be composed of three basic subsystems: Orbital Weapon Platforms (OWPS); Surveillance, Acquisition, Tracking and Kill Assessment satellites (SATKA); and Battle

Management Satellites (BM). With few exceptions these satellites will occupy only high and low earth orbits. Medium orbits will be avoided whenever possible due to the high energy particles in the Van Allen Belts which would adversely affect satellite components.

OWPS will inhabit low earth orbits to enhance kill capabilities. Defense Satellites (DSATS) will be placed in different orbits to protect satellite constellations. When necessary DSATS will independently react to attacks on BMD satellites and eliminate the aggressor.

SATKA systems will inhabit low orbits for precision acquisition and tracking. Others will be placed in high orbits for early warning, initial acquisition and tracking, and surveillance. Since data transferral between SATKA and OWPS satellites may require multiple transmissions, it's necessary to have SATKA systems in low orbit to reduce the time lag between acquisition and interception.

BM satellites must occupy high and low Earth orbits. The BM systems in high orbits will allocate the BMD system components as necessary and provide a monitoring link with the ground. BM satellites in low orbit will provide local command and control to OWPS and SATKA systems. Additionally

these BM satellites could coexist on a satellite with SATKA providing timely transferral of data and commands between all satellites and facilitating real-time reaction to attacks on the BMD system itself.

All BMD satellites in high orbits should have the capability to function as system managers. By alternating control of the system, it's nearly impossible to destroy the system manager. Likewise low orbit BM satellites can have on-board SATKA functions to provide diversity.

Countermeasures or survivability techniques apply to all systems. All satellite systems must be hardened against EMP and laser attack. Decoys are important to reduce the effects of all threats by increasing enemy uncertainty.

Stealth, self-defense, redundance, reconstitution, maintenance, and maneuver can also be applied to all systems. Self-defense and mutual defense are used to destroy threats as the threat becomes apparent. Task distribution ensures SATKA and BM systems can take over the tasks of damaged systems.

Shuttering and EHF communications are important to sensor systems. Use of these defenses enhances sensors

survivability against blinding and jamming, increase the ability to communicate in a nuclear environment. System security denies the enemy or any unauthorized user from accessing BMD systems and from tampering with data and software.

As shown, there are many methods enhancing survivability of a BMD system. While they are not inexpensive, they are necessary to retain system integrity in peace and war. Hardening, system security, maintenance, and EHF communications are essential and should be initially integrated into any deployed BMD system. The other measures are also important, but can be incorporated into the system as need requires.

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COST IMPLICATIONS, ORGANIZATIONAL CONSIDERATIONS AND WORLD REACTION TO SDI

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1 May 1985

COST IMPLICATIONS OF SDI

by

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ABSTRACT

Although many technical problems in SDI are drawing considerable attention, there is yet to be a definite figure derived for system cost. This is because no standardized, reliable or accurate method has been devised for determining cost. This paper outlines a procedure to alleviate the cost problem. The two main areas of concern in an acquisition project such as this are cost growth and cost overruns. Growth and overruns are caused by a number of factors including program changes, lack of definition, and poor estimating. Life cycle costing attempts to predict the costs of a program over its operational life by analyzing various cost-effectiveness relationships. One type of life cycle cost model is the Price System by RCA. The Price System consists of hardware and software designed to solve the problems previously mentioned. Even though the model is limited in what it can accomplish, it can be extremely beneficial in determining SDI costs if properly used.

COST IMPLICATIONS OF SDI

On March 23, 1983 the President of the United States asked the scientific community to evaluate the feasibility of a proposed plan for the defense of the United States against nuclear war. His proposal was soon labeled the Strategic Defense Initiative (SDI). While the program created many intense research efforts designed to determine the technological feasibility of such an effort, the cost implications are not yet clear. Various sources have submitted preliminary estimates. The Council of Economic Priorities reports "The total program could cost $400 to $800 billion if it goes directly into full scale development after the current 5 year R&D phase." (1:1) Other estimates from various sources range from 400 billion to 1 trillion dollars. Why the disparity? One reason is many technological areas haven't reached conclusions regarding the type of capability needed, such as the number of space-based mirrors for satellite kill assessment. Another reason is the wide disparity in the amount of information each group, making cost estimates, has at their disposal. For instance, the Union of Concerned Scientists, while composed of very competent, sincere, and well-regarded experts, does not have access to the classified information regarding the cost of technologies

and the weapon systems. The final, and perhaps the most important reasons for dissimilar cost estimates is the lack of task definition, proper estimating methods, and life cycle costing.

This study provides guidelines for the cost analysis of SDI. I will make no attempt to judge whether the cost is justified. Likewise, I will not attempt to determine the cost for a specific element of SDI. Since the crucial decisions concerning this program are yet to be made, there must be accurate and realistic cost analysis to justify deploying an SDI system. The cost of every technological breakthrough for SDI must be appropriated and allocated by Congress. If the decision-makers in this country decide to pursue SDI, they must know not only the program start-up costs, but also the long-range operating and maintenance costs. A program such as SDI contains the factors which cause it to be risky in terms of cost since it utilizes technologies yet to be fully developed. Thus the amount of predictive error or risk is quite high. High technology programs tend to be the most inefficient in terms of cost. Consequently, we have a high risk, high cost, and highly technically-oriented program. These three factors combine to produce a cost analysis nightmare.

Recently there has been a media blitz concerning government acquisition procedures. We hear about $7500 coffee makers or $600 toilet seats. While these "discoveries" of government contract inadequacy do not reveal the entire story, they are capable of arousing a great deal of public outcry concerning the ways in which Department of Defense decision makers are spending the hard earned tax dollar. Therefore, a program with as much public exposure as SDI must defend its acquisition procedures under what undoubtedly will be an enormous amount of public scrutiny.

A final thought concerning this effort deals with the conclusions I reached. Each dimension of the acquisition process explored, will be evaluated as it applies to SDI. The results will give the reader a usable, realistic product. Thus, conclusions are based on current acquisition policy. Also, with as large a research effort as SDI, I may or may not state assumptions based on the sensitivity of the material. Since the acquisition process is designed for programs likely to go beyond the research phase, this analysis is geared towards the production and operational phases.

BACKGROUND ON THE ACQUISITION PROCESS

Following WW II the developing weapons (i.e. B-52, Atlas missile etc.) involved complex technologies utilizing high cost subsystems, elaborate interfaces, and integration. (3:4) The management problems created by the new weapons were too complex for the traditional, pyramid, organization structure, so a new type of functional system matrix was designed to complete many tasks simultaneously. Since SDI involves a tremendous number of subsystems, the program demands a system matrix structure. Another reason for the development of the new acquisition process was to decrease the amount of time between the discovery and implementation of the new technology. (3:5) It's obvious SDI uses the most current technological capabilities while designing those not yet developed. A final reason for the new acquisition process is the increase in the amount of money allocated to defense contracts for research and development. In 1947 the amount appropriated for research and development was $2.1 billion. In 1970 the amount rose to $30 billion, (3:5) and by 1977 it was over $160 billion. (4:2) SDI is a research effort and accounts for a considerably larger percentage of the appropriated research and development funds than most programs.

At this point I feel it's important to make clear the distinction between the defense and commercial acquisition processes. In a commercial market the power lies with the buyer, while in defense acquisition the government is at a disadvantage. Since defense procurement involves development of specific systems over a long period of time, contractors make less on defense programs than commercial contracts. Although price is a major deciding factor in the industrial market, it is only one of many factors considered by the defense market. A final critical difference between the two types of acquisition processes involves the requirements. In the industrial market the requirements are fixed, while systems acquisition through the defense industry involves literally hundreds of costly changes before completion. (4:39)

COST GROWTH AND COST OVERRUNS

Cost overruns and cost growth on defense programs are the two greatest sources of aggravation to government officials. First, we must define what we mean by cost growth. Cost growth is "an increase in program expenditures above the price of the original program plan." (4:365) Cost growths are caused by a number of factors: 1) refined program

requirements, 2) technical problems, 3) poor cost control or, 4) poor initial cost estimates. (4:365) A cost overrun refers to the amount of money spent on a program greater than the negotiated price of the contract. Thus the total cost of a program may increase over the life of a system with no cost growth. (4:365) Both these problems are caused by the difficulty of placing a total-program dollar figure on a system not yet developed. (10:1)

The main reason for cost growth is inflation. There are two factors to consider when discussing the effects of inflation -- type and degree. (10:2) If we agree inflation is inevitable, we should consider ways to predict it. Since SDI has a long-term (greater than 10 years) deployment schedule, we must plan for the changes in purchasing power of the dollar. Two sources of statistical data ideally suited for predicting inflation are the Consumer Price Index and the Wholesale Price Index. (10:2) The Consumer Price Index is ideally suited and commonly used for long-term contracts and more importantly used by the US Government to determine its fiscal and monetary policies. (10:2) The Wholesale Price Index which is widely used in business contracts is based on the prices of raw materials, semi-fabricated products, and finished materials. (10:2) We can see the effects of inflation on defense procurement by considering the years 1965 through

1968. These years correspond to the increased US commitment in Vietnam. (10:3) During this period the US experienced one of the greatest rises in inflation in its history while the post-WW II era has seen increased annual deficit spending. This is due to the government's attempt to have "guns and butter." The implications for SDI lie in the battle of defense versus consumer-oriented program spending. Neither side is willing to give in. According to Senate Majority Leader Robert Dole:

> Only a very small group of people believe that the economy can grow out of the deficit problem. The fastest growing program in America is not agriculture, not medicare, not defense. It is the $154 billion of interest payments on the debt in the '86 budget. (10:3)

Thus, as deficit spending increases, inflation increases. The real question, in light of increased worry about deficit spending is whether the members of Congress are willing to sacrifice a terminal phase defense system for social aid. This is one consideration that needs to be addressed by upper level decision makers. During the 1960's two programs experienced the effects of inflation -- the F-111 and the C-5. Funds for the programs were appropriated by Congress during a period when inflation was only one percent. (10:3)

Estimating annual inflation rates is an involved, subjective

task. A former Chairman of the Federal Reserve System, Mr. Arthur Burns, speaks about the problems the Department of Defense experiences in estimating the costs of weapon systems:

> The causes of inflation are complex, and it is never strictly true that an increase in spending on defense or on business equipment or on any other category is the sole of inflation. In principle, the government can always adjust its monetary and fiscal policies to economic conditions so as to keep the price level reasonably stable. (10:4)

It isn't likely inflation will disappear. Even through SDI is a peace-time appropriations program, it will experience the effects of a new type of inflation. Economic experts refer to this new type of inflation as "presaging" which simply means "a continuing inflationary trend in peace time." (10:5)

With the problem identified, we must search for solutions. Analysts have tried many techniques to combat the inadequacy of current methods for predicting inflation. One simple approach used quite often is the development of a formula based on three variables -- time and efficiency gains, quantity revisions, and inflation. (10:6) This method doesn't meet the needs of a program such as SDI since it doesn't consider a contingency plan to covering the effect inflation

has in different aspects of the program. This simple approach which involves parameters for making gains in efficiency through production volumes, does not apply to a limited (less that 100) production subsystem, of which SDI contains many.

Finally, there are no means specified to calculate the predicted inflation rate. (10:7) The answer to the inflation problem does not lie in formulas applied to the contract via a clause. New cost indices must be developed specifically for the defense industry. The mix of labor skills and types of technologies unique to the defense industry demand specialization. To appropriately pinpoint trends in the critical areas affecting inflation the following need to be quantified: "geographical areas, employment and earnings subgroups, material, and the rest of research." (10:8) A program such as SDI will involves numerous types of precious materials, construction throughout the country, corporations of all sizes ranging from small business firms to defense industry grants, and long term cost allocation funds. Thus, evaluating the effects of inflation is a large effort.

A second major reason for cost growths is inadequate or lack of program definition. Too often the government changes the

desired specifications of a system well into the development phase causing significant cost growth. We expect slight specification or assembly changes resulting from government action, but changes altering the capabilities of a production system are the most costly. In 1970, 8,965 changes to major defense programs cost $1.6 billion. (4:364) To make an immediate change to a contract, the government uses a change order. (4:361) A change order is a unilateral directive to start the contractor working in return for a bilateral agreement at a later date setting a profit level for the additional work performed. (4:363) In this relationship the government is at a disadvantage. The negotiated profit rate for supplemental agreements resulting from change orders is almost always higher than the original contract.

Now that we have discussed price increases from a lack of program definition, let's explore some aspects of inadequate program identifications. First is an improvement change which adds "optional accessories" to a system. (4:369) These changes were excluded from the original proposal since including them would have made the project cost prohibitive in the eyes of the Congress. After the program is approved and initial funding begins, these features are considered as necessary for contract completion and are usually given sufficient funding since the program is already under way.

(4:369) "Gold-plating" is another type of improvement change where the cost exceeds the benefit to the system capability. (4:369) These changes are due to DOD or contractors' willingness to quickly justify any ideas that appears beneficial. A second category includes changes initiated by the system users desiring to stay ahead of the competition -- the Soviets.

Let's apply what we know about contract changes resulting from inadequate definition to SDI. First, most work on SDI is evaluating the needs of the various systems. This research encourages a large number of contract changes. Because of the huge cost of the program optional accessories may be hidden to gain initial funding. DOD officials and industry analysts must state all necessary specifications to ensure adequate cost estimates.

Gold-plating may be an unavoidable problem for SDI. According to Lieutenant General Benjamin Bellis, USAF (Ret): "at this time much of the SDI effort appears to be goldplated." (2) Since the purpose of SDI is to form system requirements, the program lends itself to contract changes. The only way to prevent changes from becoming a major problem is through organizational structure. Modifying the structure will be difficult since SDI is a multi-service program,

however, a thorough contract-type analysis and estimating procedure can help reduce the problem.

Many believe SDI is a response to a Soviet threat. If true, user initiated change will be a significant factor in system cost growth. Time is the key. Since SDI will span more than one presidential term, progress based on funding is questionable. The longer the system takes to deploy, the greater the cost growth. The value of the program lies in its ability to adjust to Soviet attempts to counter it. Consequently, we must analyze Soviet intentions and acquire accurate information regarding Soviet capabilities. Most importantly, we must not over react to Soviet technological advances. Deficit spending started during the missile gap when national security hysteria prompted huge amounts of unnecessary funding and later an anti-defense spending response.

While government related inadequacies cause cost growth, cost overrun usually occurs due to contractor shortcomings. The effect of cost overruns on the government is indirect. While the contractor experiences a direct net loss on a project, the government is concerned with the effect the overrun will have on the deliverable item. Often a contractor will cut corners to avoid a loss or time delay which results

in more significant problems when the system is found inadequate and in need of redesign. Overruns occur as a result of the wrong type of contract, an improperly negotiated profit rate, or poor source selection. Poor source selection is choosing a contractor incapable of performing the assigned tasks within the time and cost restraints. Profit is determined different ways for different types of contracts. Since SDI requires accurate, dependable systems, it is essential contractors avoid the shortcomings which cause cost overruns.

LIFE CYCLE COSTING

Several trends developed in the military as a result of the failure of the defense budget to maintain pace with inflation. Personnel costs have increased to over 50% of the defense budget compared to 40% in 1960, while at the same time the manpower strength has declined. (6:2) Thus, the share of the defense budget allocated towards purchasing hardware has declined. A 1976 study pointed out if this trend continues, funds allocated to defense in the 1990's will be spent on the maintenance of existing systems only, with no money available for new systems. (6:2)

While the growth of the defense budget has kept better pace with inflation over the past few years, the concept of life cycle costing has gained increased attention. Life cycle costing predicts or forecasts the operational cost of a system over its entire service life. Air Force regulation 800-11 defines a life cycle cost as: "...the total cost of an item or system over its full life. It includes the cost of development, acquisition, ownership (operation, maintenance, support etc...) and, where applicable , disposal." (6:23) Operating costs involve all costs associated from initial development to final salvage value upon retirement. Life cycle costing can apply to the SDI cost evaluation effort. While SDI will involve both space and ground-based systems we will need a larger allocation of manpower to keep these systems operating at peak efficiency. Consider the effect of an operational system falling below accepted readiness levels. This would undoubtedly degrade the effectiveness of the entire layered defense network threatening national security. An SDI network will do little good if the proper level of funding were not appropriated for its continued operation.

Thus, we see life cycle costing involving future costs; therefore, there is a great deal of uncertainty on what we should base our evaluations and how to interpret our

results. (6:5) One way to reduce some of the subjectivity of this type of analysis is through computer modeling. (6:5) This paper will present information on one of the computer models called the Price System. Life cycle costing can be used for more than major weapon system procurement. We can use the model as a management tools to support program decisions such as:

> The selection of contractors, the evaluation of engineering change proposals submitted anytime during the life of the weapon system, and assessing the progress of a weapons system during the acquisition process. (6:25)

For these types of analyses, life cycle costing can be used in the cost and benefit evaluation comparing acquisition versus operating and support costs. (6:25) Life cycle costing can also be used on subsystem units. Since SDI proposes the use of an elaborate, integrated network of operational systems and subsystems, life cycle costing has enormous potential for this program.

Life cycle costing is not the only method for lowering costs; combined with other techniques, the effectiveness of a life cycle cost analysis increases. Three other methods seek cost reduction through planning -- reliability and maintainability, integrated logistics support and design-

to-cost. The real benefit of a system maintaining a high level of reliability is the "force multiplying effect." (6:11) With SDI systems, the operational readiness-to-capability ratio will not be a one to one relationship. for instance, if the readiness of a space-based, laser-satellite, kill mechanism is only 90%, the 10% decrease could cause the capability of the overall system to decrease 30%. The alternative to maintaining operational efficiency is to purchase a larger number of system components at an enormous cost based on the current figures for the cost per pound for the system. In the past, the numerical reliability requirements were emphasized. (6:12) This involved a series of costly tests to determine if reliability specifications were within the confidence levels. (6:12) If these requirements were not met, it meant costly redesign and contract changes. Because of this high correction cost, the emphasis has changed from testing reliability to designing reliability. (6:12)

Just as reliability can act as a force multiplier, so can maintainability. (6:13) The most important area is user-oriented design. A system must be designed with the maintenance personnel in mind. Too often new technology systems loose effectiveness because they cannot be repaired or replaced easily. The F-111 is an example of such a system.

Since SDI will involve the newest technologies, maintainability may present significant problems.

Integrated logistical support should be addressed in conjunction with the life cycle cost evaluation. Integrated logistical support includes:

> maintenance planning, special tools and test equipment, spares support, transportation, technical data and the personnel and training needed to support the system, subsystem, or item of equipment after it is placed in the hands of the operator. (6:14)

Planning starts during the development of the system and combines many management approaches. Due to recent publicity surrounding the high cost of replacement parts for operational defense systems, concern for integrated logistical support will increase in the years to come. We can only speculate the high cost of space-based or elaborate ground-based, anti-ballistic missile components. When evaluating the cost effectiveness of lasers, we measure the cost-per-watt of power produced. Lieutenant General Abrahamson states we have made significant gains in reducing the development costs for laser weapons, but we haven't found substitutes for many of the precious metals used in manufacturing the components of these systems. For instance, titanium is the main component in most spacecraft vehicle frames, however, we import most of our titanium at a very high cost from the

Soviet Union. Additionally, the Air Force must re-evaluate and streamline its spare parts system. Indirect costs such as overhead expense and facilities maintenance have led to $500 hammers and $7500 coffee makers.

A third technique used in conjunction with life cycle costs to enhance efficiency is the design-to-cost method. The definition of design-to-cost, as stated in DOD directive 5000.1 is:

> A management concept wherein rigorous cost goals are established during development and the control of systems costs (acquisition, operating and support) to these goals is achieved by practical tradeoffs between operational capability, performance, cost and schedule. (6:18)

In the design-to-cost method the program manager establishes a specific design-to-cost goal which, if approved, becomes part of the contract negotiation. (6:19) The goal is a "specific cost figure based on a given production quantity and rate." (6:19) Since design-to-cost trades performance for cost and relies on a large volume production, it does not apply to SDI.

Since we are aware of life cycle costing and the techniques used, we will explore some of the end products or benefits

of life cycle costing. One factor in the life cycle costing model is the mean time between failures (MTBF) or "a measure of system reliability." (6:26) As the MTBF increases, the life cycle costs decrease, but the associated research and development costs increase. (6:26) These costs would be analyzed in greater detail so funding for research and development can be supported through evidence of cost efficiency when the system is operational. Since SDI is tagged as a research effort, one of the key selling points of the operational system may include operating effieiency.

Life cycle cost estimates can indicate the "size and relative amount of resources required for the development, production and operational phases of a system." (6:28) Since acquisition programs are front-loaded with research, it's important to consider life cycle costing early during the evolution of a system. (6:28) Initially in a program, there is a large outlay of money and a high degree of risk, thus, the program manager "needs some tool to assess tradeoffs relating performance and design characteristics with operating and support costs." (6:30) He has two choices -- he can rely on the experts for answers or he can utilize life cycle costing techniques along with expert opinion. (6:30)

The most common life cycle technique is simulation, or the

use of models. While this paper will examine one specific model, I will address generic principles of model's used and their operation. Although the degree of complexity varies for each model, a model must "achieve a balance between simplicity and accuracy to answer the what-if question." (6:31) A model can cover estimates for labor and material, detailed engineering analysis, historical data, accounting procedures and expert opinion. (6:31) One key point that must be remembered is models do not make the decision nor should they be used as the sole basis for a decision. (6:31)

There are several different types of cost models. For example, one type of specialized model is the maintenance manhour planning model. (6:32) This model predicts the cost effects of varying the parameters associated with maintenance, such as the inventory of spares and skill levels of technician. (6:32) Several specialized models can be combined into one total program model. One important point is that life cycle costing is based on theoretical, not actual cost factors. (6:33) As we will see when we talk about estimating cost for proposals, the fact that SDI involves work never before performed makes this dimension of life cycle costing very attractive. Life cycle costing is used more often and has become recognized as an important and useful management tool.

The implementation of life cycle costing into the acquisition process has just begun. To start with, the models must be fully understood to be effectively employed. We must remember the principle of any life cycle cost decision involves a cost-effectiveness analysis.

There are two general types of problems that need to be solved in the acquisition process -- technology and strategy. (7:5) Technological problems involve science and engineering. The specific areas of concern are: "accuracy, consistency, validity, ease of computation and capability of data". (7:5)

While the methods used for solving the specific areas of concern vary according to the program, several other trouble areas can usually be alleviated with a life cycle cost model. One area is discipline. To prevent the program from experiencing overruns, certain steps must be taken, such as: "direct monetary penalty, supplies of extra spares, price adjustments, corrections or contract termination." (7:10) If action of this type is used along with an evaluation model, life cycle costing gives us a defendable prediction which should play a major role in source selection. (7:10) If the program is below cost, based on the life cycle costing model, the contractor may be rewarded with a bonus or

award fee. This application of life cycle costing can make the difference in a program such as SDI which involves vast amounts of research. Research work profit is negotiated on the basis of incurred costs. Quite often the government attempts to set ceilings or make incentive plans that fail primarily because the ceilings or incentive plans can not be supported. A second major benefit of using life cycle costing is the identification of contractor inadequacy and thus the prevention of poor source selection.

Another problem life cycle costing can solve is the lack of a data bank. Too often the government asks the contractor to make proposals about the technology of a system when there isn't sufficient data. (7:10) Since life cycle costing information is not submitted until the prototype of a system is analyzed, the contractor will have more detailed information available before proposal submittal. Of course there will be modifications to the design, but these modifications will not involve any new parameters and therefore the changes in life cycle costing will be insignificant. (7:11) Many companies involved in the current SDI effort are using their own funds to support the development of SDI technologies. Because of their initial efforts they will have a reasonable estimate of what their system hardware involves; consequently, their analysis will be quite beneficial.

A third problem involving subjectivity and the likelihood for overruns and cost growth is in setting contractual requirements. When establishing life cycle cost related requirements the winning bidder's proposal should not be evaluated in terms of the individual components or even the completed product, but rather the complete system's life cycle cost. (7:11) Once figures are adjusted for such factors as inflation and present value, the dollar figures are equal in magnitude and hence tradeoffs may be analyzed by detailed requirements. (7:11) Earlier I mentioned the importance of analyzing the reliability and maintenance of a system. Requirements of this type are usually "imposed at the black box level and at the individual functional level." (7:11) Detail prevents us from properly analyzing the different possibilities available. Reliability and maintenance requirements were arrived at by using the data from similar systems. This method poses a problem for SDI with its unique weapons systems.

As we try to increase reliability and maintenance, costs in other areas of the program, such as research, and thus the final life cycle costing price, become higher. Because cuts were made in some areas, the overall effectiveness of the system decreased below that of a lower reliability and maintenance program. (7:12) Therefore, we see the effect of

concentrating on one performance parameter. Since national defense is at stake, system effectiveness is solely capable of determining the strength of an SDI system either through demonstrated capability or deterrent effect. By basing the system requirements on total life cycle costs and total system effectiveness, new information and data may be more readily assimilated into a cost effectiveness type analysis. We are therefore able to conduct in-depth analyses on a particular facet for the program. If a single individual item needs to meet additional requirements in other areas such as safety, the additional requirement can be combined with a condition common to the total system to form "a combined umbrella" requirement. (7:13) This would allow system upgrading while maintaining cost effectiveness.

Another use of life cycle cost estimates is for pre-award motivation. The goal of all proposal bidders is contract award. Minimization of life cycle costs shows efficiency and is a major pre-award consideration. Contractors will be motivated to minimize life cycle costing. To ensure a favorable, source selection board, recommendation they will try to make prototype data conform to their bids making life cycle costs a design tool. (7:13) This will reduce the problem of underbidding to gain awards and of relying on cost growths and overruns. "It is believed that the life

cycle cost model can effectively communicate the Government's desires to the contractors -- a matter which has been very difficult in the past." (7:14) Post-award motivation can also be created using the life cycle costing model. Once the contract has been awarded, incentives should be established to encourage the contractor to make design changes which will benefit both himself and the government. (7:14)

Engineering change proposals discussed earlier in this paper will benefit from life cycle costing. The approval of such changes is normally based on feasibility, input, and payoff. (7:14) The life cycle cost model can evaluate the entire cost including parameters on which the original decision was made. (7:14) Quite often even if a change will adversely effect the original life cycle estimate, it will be approved for various reasons including need, above cost. When such decisions are made, the possibly adverse impact is decreased if the estimated costs are as reliable as the values for the life cycle cost bids. (7:14)

As discussed earlier, the life cycle cost model permits us to single out the parameters for items being considered while leaving other factors constant. Throughout this discussion I emphasized the total life cycle cost. Provisions

in government acquisition procedures call for detailed parameters to arrive at life cycle cost figures and the rationale for each. Although the figures are not contractual they are goals and reference points. (7:15) The life cycle costing models provide means by which we can prevent cost growth and overruns. These models can be used in hundreds of ways; those outlined above are intended to solve some of the problems posed by SDI. One of the difficulties in arriving at an accurate and reliable cost estimate for an SDI deployment phase system is that it involves several programs at various stages of completion. Detailed life cycle costing overcomes this difficulty while permitting DOD planners the flexibility to alter one or several parameters without re-evaluating system cost or effectiveness. At the same time we have effective, justifiably defendable methods to prevent growth and cost overrun. While life cycle costing is a later step in the acquisition process, simple individual system cost estimating is performed earlier and establishes the basis for life cycle costing estimates. The next section of this report will explore the different types of cost estimating and the implications they hold for SDI.

COST ESTIMATING

Accurate and reliable cost estimates must be available to the decision makers and acquisition planners in the military. "Adequate cost estimating depends on the availability of people and methods for making the estimates." (7:154) Cost estimating also relies on modern techniques for ensuring reliability. As mentioned earlier poor cost estimating is one of the main reasons for cost growth.

At this point, it's important to differentiate between cost and price. Price refers only to the contractor's cost without the negotiated profit. However, the term cost is generally used to denote the contractor's expenditures as well as the predetermined level of profit. (7:155)

There are several phases in the estimating process. The first type of estimate is the planning estimate. The planning estimate is used to determine if program should progress from the conceptual phase to a more advanced validation phase. (3:12) This estimate is the initial estimate. During validation of the preliminary design and engineering, the development estimate is formulated. As changes are approved, the development estimate is modified to show the results of changes. This is known as the current estimate.

(3:12) According to a 1975 study, 30% of the cost growth in major Air Fore acquisition programs is due to estimating changes. (3:12) These changes are the result of revisions caused by math errors and revised estimating relationships, not by changes in other program areas such as engineering or schedule changes.

Valid estimates provide a reliable basis for deciding what systems to modify or stop. According to a recent professional study on cost control, there are a number of reasons for poor initial cost estimates on major programs in the Department of Defense. They are:

1. Improper task identification.
2. Accepting estimates from only one source.
3. Lack of adequate data.
4. Inadequate prediction and preparation of program uncertainties.
5. Lack of organized estimating procedures.
6. Biased review of estimates. (3:12)

This report highlights some of the reasons we must have adequate program definition. The primary reason is estimating. Just as the initial step in the contract phase is contract definition, the initial step in the estimating procedure is

defining the estimating task. To accomplish the task, we must gain information about "the system description, the ground rules and assumptions, and enough information to determine the purpose and scope of the estimate." (3:13) An adequate system description evaluates all relevant performance parameters.

SDI involves some space-based equipment. The approximate cost to deploy a satellite is 40 thousand dollars per pound. A mistake in a program this sensitive to increased cost could produce a huge cost growth factor which is then converted into delays. SDI will involve a considerable number of agencies and support companies throughout the country. These supplemental organizations must provide cost estimates as well. Once the data is collected from the various organizations, it must be filtered to ensure accuracy and continuity. The problem with data made available to the cost estimator is validity. Before using any data source, an estimator must ensure "they reflect current costs, are directly related to the systems specifications and performance characteristics, and they are unbiased." (3:15) Although there is an abundance of data available, there has been little or no effort to collect the data systematically. Computers should help to alleviate this. With all of the efforts to account for the variables involved in a program,

there are still uncertainties. It is critical that we develop an appreciation for the effect data will have on the outcome of the program.

There are three types of cost estimates. The first type is parametric. Parametic estimating uses data from previously constructed systems to predict the cost of future systems based on certain parameters. Interrelationship is the most important characteristic of parametric inputs. A change in any one parameter is usually not localized to one cost element but may have a direct effect on several cost elements and an indirect effect on many more. (4:56) A typical parametric model contains thousands of mathematical equations relating input variables to cost. This estimating technique is most effective when there is a limited amount of engineering analysis available.

Parametric estimating also exhibits several shortcomings. "Since they are based on the actual cost of previous systems, they can be no better than the historical data used as input." (4:154) Since SDI is utilizing the foremost technology, models may be obsolete by the time they're used. (4:157) There are a number of pitfalls in applying parametric estimating to the Strategic Defense Initiative

program. First, the data may not be updated to reflect an efficiency or learning. In addition, since many elements have never been purchased the risk assigned to the various elements is increased and more vulnerable to errors in accuracy. Finally, with the increased amount of technological risk, a totally non-biased estimator is more essential.

A second type of estimating technique is the engineering estimate. This technique estimates cost by dividing the proposed system into many subcomponents and by analyzing the specific work for each, or uses parametric estimating techniques on a system that has been broken down. Since the estimates are tailor-made to meet the requirements of a specific program, the margin of error is less than it would be for parametric estimates. (4:157)

Engineering estimates are not without shortcomings. This estimate "involves many detailed analyses and runs the risk of becoming inflated through failure to identify the contributions of managers at each level of summation." (4:157) There are also several problems when this estimate is applied to SDI. Experience in large acquisitions programs indicates the Department of Defense does not analyze contract proposals well, especially in predicting cost overruns. DOD officials are overly optimistic and biased

towards engineering estimates. Additionally, the secrecy of the SDI program restricts the competitive nature of bids and thus reduces any basis for comparison based on engineering approaches.

The third type of cost estimate is the learning-curve estimate. This estimate uses the cost of identical units produced in volume in the past. Over time it is expected that the cost-per-unit volume will drop based on greater efficiency with increased quantity. The advantage of these estimates is that they are easily formulated and used. (4:157) The disadvantage is that they "project past experience into the future, whether or not that experience is based on reasonable and efficient operations." (4:157) Cost estimates are used for the production of several identical units. A defense system such as a system of radar homing terminal phase missiles can use the cost estimating technique.

Thus we have the tools to get the job done, but we are faced with considerable problems. We should realize no single estimating technique will solve all problems posed by SDI. The best approach may be to use parametric and engineering estimates in a combined approach that establishes a system of checks and balances utilizing independent should-cost

estimates and analyses. To do this the first requirement is to identify potential problem areas. While the technical aspects and problem areas have been addressed, the potential cost assessment problems need to be accounted for. Secondly, the requirements and objectives of the program must be specifically identified to avoid spending large amounts of money without a clear direction. Thirdly, milestones for performance and cost must be established and procedures for rectifying inconsistencies must be developed. Finally, and most importantly, there must be integrity within the command structure. When all factors would lead the informed rational man to believe that the SDI program is not feasible, commanders at various levels should, based on the information provided by cost estimates, recommend not to continue with the program. (5)

Thus we have examined one small aspect of the SDI program, that is, the cost estimating process. We must account for the problems of cost estimating and deal with them in an effective manner to determine the likelihood of success. A program this important to our nation's national security must not escape any aspect of critical analysis.

EVALUATING MODELS

Before judging the pros and cons of a model, we must select the model we wish to evaluate. The purpose of a particular program determines how a life cycle cost model will be used.

> For new subsystems or new system developments, the key to choosing a life cycle cost model is the extent to which the program manager can make a direct comparison between costs for some existing subsystem or system and the one he will be developing. (6:74)

The degree to which the parameters and elements of a previous model are used as the basis for a new program is determined by the program manager. Remember that life cycle cost models are approximations rather than absolute predictions. When evaluating the quality of a model based on its complexity, a model with a few accurate and reliable elements is more effective than one with many detailed elements of questionable reliability.

There is a general purpose life cycle cost model which can be applied to a wide range of different programs; however, the model does not provide detailed solutions to the cost problems of a specific design issue. (6:74) It also fails to identify the effect of unique or specific characteristics of equipment. Too often the model requires data in a dif-

ferent format than used for the system evaluation methods in operation at that time. (6:75)

Another factor to consider when selecting a model is the strategy that characterizes the acquisition nature of the program. This involves "the basing and dispersal concept, the maintenance philosophy to be used, and operational concepts to the extent that they influence system costs." (6:75) The model chosen should be designed for the entire acquisition process. At the same time the model must not be over-institutionalized, but should be designed in a definite configuration. (6:79) While testing occurs and the performance and reliability factors change to reflect redesign and design concessions, the model must be revised to reflect what is learned from the test data. (6:81) One thought repeated many times in this report is "the accuracy of a life cycle cost model depends on the accuracy of the data that is used for its construction." (6:82)

The Air Force uses several weapon systems where life cycle costing has been effectively implemented. For instance, the decision for a single engine in the F-16 was the product of extensive life cycle cost analysis. (6:95) The engine allowed a 15% weight reduction, and a 50% instrumentation reduction while causing no significant difference in

accident rates. (6:98)

Now we will turn to the evaluation of a specific model, the RCA Price System.

THE PRICE^{tm} SYSTEM

The three essential elements of the Price System are computer software, total life cycle support costs (hardware and software), and custom micro-electronics. All Price models use the parametric approach to estimating. (11:2) The concept of parametric prediction has already been discussed in this paper. A company maximizes the use of a parametric model by fine-tuning and calibrating the model using exact values obtained from the organization's past experiences. (11:3) The calibration feature provides a cataloging of past experience. The features common to all Price models are:

> Rapid response; what-if analyses tradeoffs; emulation of conventional processes; conversational dialogue; comprehensive documentation; system-oriented, easily available input data; and easily-calibrated, built-in escalation and technology advances. (11:4)

According to estimates by several organizations, use of Price products has achieved a time savings of 8 to 12 times over conventional methods. (11:5-6)

At this point we will examine how we can use the Price System to evaluate SDI. One model of the Price system will be used to estimate the cost of actual hardware. This system has been successfully used for lasers, and satellites. For the past ten years Price has been used on the Space Shuttle program. (8) Thus it will be able to give accurate estimates on the cost of the heavy boost vehicle needed for deploying space platforms.

Currently the Unites States' most powerful launch vehicle is the Titan booster. Even though the Space Shuttle can carry more cargo into space than the Titan, it still falls hopelessly short of the needed weight for SDI. The cargo capacity has to be doubled to deploy many of the proposed SDI systems. To help determine costs to meet payload requirements, the Price model can be used since its greatest strength is the parametric nature of its catalogued data. Most of the technologies involved in SDI are sister technologies of work currently in progress or deployed. For example, the Lantern system, developed for aircraft by the Loral Corporation, taught defense planners a great deal about radar homing.

The Price system will help planners to predict the tradeoffs

necessary to maintain system effectiveness. For example, where can we cut cost without sacrificing the security of our country? Price will help provide the answers.

The Price System has been used in many satellite programs. In the early 1970's when we were confronted by an energy crisis, NASA explored the possibility of harnessing solar power through the use of satellites equipped with photovoltaic cells, constructed in a low earth orbit, and deployed to geosynchronous orbit after completion. The electricity produced would be converted to microwaves and beamed to earth. The Price System was used to develop an estimate for the cost of this program. According to Mr. Peter Korda, a manager with Price in Hollywood, California, NASA's proposal contained many of the technologies that will be used in the future SDI space-based platforms. (8) The only area that may pose a problem for the Price model is the power requirements for SDI systems. It is currently estimated a satellite costs about $40,000 per kilogram to deploy, yet the power generation needed for space-based lasers, particle beams, and kinetic energy weapons poses severe problems. To this date there has not been a deployed system which demands vast amounts of power in a limited amount of space. (8)

The Price model can be used to evaluate the cost of computer

software in systems. This is extremely important in the command and control of the SDI layered defense system. For instance, it is estimated the friend-or-foe identification computer aboard the satellite kill-assessment system will process over ten million logic decisions in one second. (8) The cost to develop such a system will be enormous. The Price model can also estimate the cost of ground systems for tracking satellites, for identifying incoming terminal phase warheads and for defending against these threats.

As the threat changes our SDI system must be able to respond through low cost adaptations. If we thoroughly evaluate the program changes in terms of effectiveness, cost, ease of deployment, feasibility and future maintenance considerations, we can maintain the readiness of the system and our national security. As previously discussed, program changes have a devastating effect on system cost. By using the Price model we can evaluate the life cycle costs of the software for SDI. In light of changing administrations, we must plan for smaller allocations by projecting future costs based on our present knowledge. (8) Since the Price model can also be used to evaluate the feasibility of systems yet to be built, we can use it in today's SDI research effort.

In conclusion, we cannot treat SDI simply as any other

acquisition program, we must provide an accurate and reliable estimate of costs involved with this program. In the words of President Eisenhower, "we must not destroy what we are seeking to defend". Our country cannot and will not tolerate the spending of huge sums of money on research and development for a program that is doomed to failure because of huge costs. (8) If the cost analysis of SDI is given as much consideration as many of the technical aspects, defense planners will be able to justify their decision regarding the most important defense program of the century.

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ORGANIZATIONAL CONSIDERATIONS

by

Cadet Keith Knudson

ABSTRACT

This study assumes the Strategic Defense Initiative will reach maturity and become an operational program. In this context, strategic, doctrinal, and hence organizational implications cannot be neglected. At present the program is driven by technological factors and, to a degree, for good reason. However, without conscious parallel development of strategy and policy at all levels and through all phases, serious problems will arise. In the present research phase, the notion of "technicity" has created organizational uncertainty that will surely allow the initiative to default to parochial bureaucratic interests.

An environment of interservice harmony has developed -- a condition which is deceptively beneficial. In a research phase, cooperation tends to develop better products. The same is not necessarily true once deployment and, later, operations begin. Bureaucracies tend to insulate and consolidate their structures, especially in times of uncertainty. The philosophy currently adhered to within the Strategic Defense Initiative Organization is clearly that SDI is simply a research program. This position allows for considerable uncertainty and bureaucratic progression unguided by policy or strategy. Therefore, it is vital that a strategic doctrinal concept, with provisions for appropriate organizational arrangements, be developed along with SDI technology to reduce uncertainty and implementation problems.

ORGANIZATIONAL CONSIDERATIONS

A look at the organizational considerations of the Strategic Defense Initiative, in isolation and only in the context of organizational factors, would ignore the very point of my study. It is difficult to plan and organize for an organization which you don't necessarily understand or, which fails to have a specified and designed purpose. My study is heavily influenced by policy and strategy considerations. It is important to note my references to policy and strategy are on a national and Department of Defense level, not merely on the Strategic Defense Initiative Organization level.

I do not intend to structure or provide a canned organizational body or wire diagram. This, in light of the present stage of SDI, would be trivial. I will, however, direct my efforts towards questions and considerations for the program. The subtleties of organizational growth and interactions, characteristic of bureaucratic structures, will form an important part of my study.

Finally, I will assume SDI to be a program surviving the research phase and moving to deployment. This position will allow me to see beyond the prevalent statements which label

the SDI as strictly a research program with, no planned future.

THE TYRANNY OF "TECHNICITY"

For a variety of reasons whether political, institutional, or economic, the SDI has been labeled and presented as merely a research program. With the purpose of vigorously seeking new technologies, the initiative has won wide-spread praise for its accomplishments. In the traditional American fashion, pragmatic problem solving has answered questions, some not even posed, at a surprising pace. New developments have led to more open doors which have spurred on new studies. Some have praised the various agencies harnessing the immense American technical community, and have speculated as to what must lay ahead.

The praise and sense of accomplishment is not unfounded, but, to a degree, it is in recognition of the expected. The United States is capable of great advancements and, given the proper incentives, there is little we can expect not to obtain. However, to apply Edward Luttwak's words, "technicity is a wonderful servant and a disastrous master." (1:265) The notion of "technicity" suggests continuously

researching to technically discover the optimal solution, and relegating strategy considerations to a lesser importance. The concept of "technicity" is the hub from which both the SDI program's direction and organizational inertia have originated. Technical excellence is a driving force for the SDI. Perhaps to a greater extent than ever, technology must provide feasibility and framework for strategic defense policy. Clearly, the magnitude of this program far exceeds any which the DoD has ever undertaken. However it is essential technology developments alone not dictate direction. It seems clear that without coherent strategy and policy in the research phase, planning the next step or phase includes solving the previous step's problems. But, on the DoD level, policy and planning must be long-term. They must connect the diverse issues of technology, policy, and bureaucracy into a coherent statement of the future. And, to be complete, the DoD must align developments and plans at all levels to develop a national strategy.

THE PRIMACY OF STRATEGY

From a national strategy standpoint, a well-defined picture of the future is necessary to plan and organize for its needs. Transitioning from a doctrine of mutual assured des-

truction to mutual assured survival involves uncertainty of the highest order. Shortly after President Reagan introduced the SDI, two studies were commissioned to consider the implications of carrying out such an initiative, as well as the long-range effects on issues of technical feasibility, policy, and strategy. The Fletcher Panel, which was the most publicized of the two, concluded the program to have great technical merits. The second, the Air Staff Policy and Strategy study, concluded that SDI, an initiative to drastically change strategic doctrine towards nuclear weapons, represented a potentially perilous course which was not possible without strict arms control strategy and agreements. The study also concluded the program may increase offensive warheads reaching a level which could possibly overcome a strategic defense system. (2)

Consequently, technical feasibility is not the only prerequisite for an effective and viable strategic defense system. The uncertainty of political reactions, as well as interagency utilization and participation, must be considered. We must compensate for uncertainty by strong policy and planning at lower levels as well as by a deliberate organizational structure which can navigate through the transition period. The organization must avoid giving either side an incentive to strike first during a period of

strained relations or hostility.

How this is to be achieved is one of the biggest challenges facing the implementation of this doctrinal shift. But, of course, a safe transition will not occur by developing and deploying technologies. Organizationally, we must plan for the receipt and integration of these systems. Since SDI is strictly a research program with the SDIO as its management body, there are no traditional, documented plans for transitioning into development. (3) It is easy to cite individual organizational planning efforts across the DoD, but none have been all-encompassing. For example, given a space-based, directed-energy system ready for deployment. How will the various agencies be organized to efficiently "hand-off" the system to the specified operating command authority? And, what will be the inherent bureaucratic forces which will effect efficient implementation? An organizational body capable of these requirements does not initiate complete pre-processing and planning. It does not, as well, require a deliberate and clear-cut environment. Attempting to plan every move within a given environment defies even our individual experience. However, establishing within the services and agencies of the DoD, policy towards efficient implementation is not inconceivable.

Research developments indicate that a comprehensive defense posture will entail some form of space, atmospheric, and terminal distinction. The Unified Space Command, which was created independent of SDI considerations, has the purpose of consolidating Air Force functions such as satellite and space shuttle operations. The advent of this unified command is important in an operational sense, since it ensures a war-fighting capability in the organizational structure. A unified command is tasked with developing operational plans for war. The commander-in-chief of a unified command has control over the land, air, and sea and would be tasked with delegating responsibility of the command's assets.

Though it is assumed the Unified Space Command will have control over space-based assets, it is unclear whether the other service's assets will be directly under the organization's control. (2) According to today's philosophy, the Air Force component of an SDI system is logical due to its existing assets and general trend in mission. However, both the Army and Navy also have assets, experience, and interest in SDI and any future strategic defense system. Consequently, all three services have been deeply involved in SDI.

THE CACOPHONY OF INTERSERVICE HARMONY

The SDIO falls under the Secretary of Defense for a variety of reasons, one of which is of particular interest. For a program of such magnitude and scope, placing all efforts under one service would be inefficient given the previous work done by all three services. Since the program began, there has been cooperation in researching among the services. However, what's organizationally good for a research phase, may not necessarily be good for an operational phase. I feel interservice harmony is present and developing within SDI. On the surface, this appears to be a good sign since cooperation tends to develop better relations and products, especially in a research phase. It's easy to see problems develop when deployment gives way to an operational system, however. I feel the present philosophy of the SDIO and the Department of Defense will create serious problems once the hard decisions is made as to whom will have control and, more importantly, who will benefit from operating the system. The philosophy of cooperation in technical areas is directly linked to the theory of "technicity." There appears to be, in fact, a casual relationship between the apparent lack of policy and planning in doctrinal and strategy concerns and the interservice harmony I suggest exists. Given the present environment which lacks structure and

policy, each service will try to maintain its own domain while continuing to cooperate. Cooperation reduces pressures to give up what they control for the benefit of the program. By pursuing a course of "technicity," concentrating on the technical aspects, and de-emphasizing other concerns, interservice harmony is strengthened.

A bureaucracy tries to insulate itself against the environment and consolidate, in a conservative way, its interests and assets to ensure a long and stable life. The present SDI bureaucracy can effectively insulate the jobs and offices it created from absorption by the agency which will ultimately take control. Obviously, once the program is ready for integration and operation, there will be a great deal of resistance and lobbying to maintain the status quo. There won't be the need to justify its existence, but rather the need for the controlling agency to justify changing the status quo. The operational agency will find a tough task in attempting to organize a system which has been subdivided and jealously protected by an existing bureaucracy.

RHAPSODY IN PLANNING AND POLICY

SDI has been driven by technology from the start, but this

is not inappropriate for a program such as this. An approach however, accenting "technicity" is difficult when the time comes to integrate the system into an organization which is tasked with incorporating the technology into a doctrine or strategy. To be successful, the organization must have a strong doctrinal base to be effectively absorbed into a greater strategy.

CONCLUSION

I've argued that today's SDI program lacks planning and policy which has led to "technicity" as a driving force. As a result, bureaucracies have been formed protecting their own interests. I feel the SDIO needs a parallel organization, with an equal effort to develop doctrine and policy along side new technologies to reduce the uncertainties of operations. This task is not an easy one. Agencies and offices must be formed to develop policy which will help transition to an operational organization. The Unified Space Command is a structure which is consolidating pertinent assets and missions in line with an overall strategy in the utilization of space. Perhaps the time has come to begin planning for the assignment of a strategic defense system in this command. Unfortunately, there will probably be great resis-

tance, even at this stage in the program. Through strong policy decisions at the Secretary of Defense level, increased resistance, which would come with time, can be avoided. All three services may become involved in the operations of a strategic defense system. However, control is the important consideration. Through coherent strategy, doctrine, and planning, cooperation can be attained through understanding, direction, and acceptance, and the organizational uncertainty which has been produced in this air of "technicity" will greatly decrease.

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SELLING SDI TO OUR EUROPEAN ALLIES

by

Cadet Richard C. Keller

SELLING SDI TO OUR EUROPEAN ALLIES

Since President Reagan's announcement which began research on the Strategic Defense Initiative, or the "Star Wars" program, most of the media focused on the domestic reception or rejection of the program. Concerns surfaced such as how the program will affect the economy in terms of the growing deficit and how the system, if deployed, will affect stability in the world today. Not until recently has attention been focused on the reaction of our NATO allies to SDI. Europe is significantly affected by a possible shift from offensive to defensive deterrence. Realizing that the support of our NATO allies is almost as important to SDI as is domestic support in the US, the Reagan administration has been trying to gain approval among the leaders of the NATO countries. While the European reaction has been favorable, most of our allies hold reservations, fears, and questions regarding SDI. This paper will discuss NATO's fears and reactions, and the best possible courses of action for the United States to gain Europe's approval for the deployment of SDI.

As one would expect, a proposal which drastically shifts the deterrence stance of the US, arouses many concerns among our

allies, especially in the area of collective security. The greatest European fear is the unilateral development of a defense system by the US leading to a "Fortress America," or an abandonment of Europe by the US. (10:20) In a recent speech, West Germany's chancellor, Helmut Kohl, gave qualified support for SDI, saying he favored the current research program. He also stated, however, that he expected any decision to deploy SDI be based, to a large extent, on NATO's unity in the matter. These words are an excellent example of the widespread European fear of SDI. Could SDI reduce the United States' interest in the defense of Europe, and build a "decoupling" effect on the NATO alliance? (4:45)

Europe's fear could become a reality if the US and the USSR simultaneously deployed comparable missile defense systems. If this were to happen, the chances of a limited European war, using both conventional and theater nuclear weapons would increase even if SDI were capable of defending not only the US but also Europe. As a result, SDI detracts from the deterrence NATO has been building since the early 1950's, and shifts the emphasis to conventional warfare. (5:60)

Another European fear is the Soviet response to defense systems. With effective US and Soviet defense systems, the

Soviets might feel less inhibited in launching a conventional attack in Europe. A war between the superpowers in Europe would probably result in vast destruction to European countries. Consequently, Europeans want deterrence, or the avoidance of open hostilities, and get nervous when the US speaks of defense. (10:21)

NATO is concerned that the US is giving too much attention to SDI and diverting attention from improvement in the conventional forces in Europe. As Lord Carrington, the general secretary of NATO, stated, "So much for the stars. One of my concerns is with the relative strength of our conventional forces." (2:34) A NATO staff member has said that the combined NATO conventional forces in Europe could only last for fifteen days in a war, but others feel the NATO forces "more likely could only last for twelve days". (2:34) A related European fear is that the money used to research, develop and deploy SDI will take away money from US armed forces, affecting the US forces in Europe. If US forces were reduced in Europe, our allies would be hard pressed to compensate for the reductions.

A Soviet missile defense system built in response to the United States' SDI could prove particularly damaging to Great Britain and France, since both countries' small,

independent, nuclear arsenals would become useless. Both countries would lose their capability to act in their own interests. (10:20) While the French defense minister, Charles Hernu, fears SDI will cause an accelerated offensive arms race, some think what really bothers him is that a Soviet defense system built in response to SDI, will make his country's nuclear force obsolete. (4:45) Likewise, the British, who have always strived to maintain an independent nuclear force, will suffer a similar setback especially since they made the decision to replace the antiquated Polaris SLBM's with the Trident. (10:23)

This is but one of the concerns of the British and French. Prime Minister Margaret Thatcher of Great Britain gave qualified support to SDI during her recent trip to the US, saying she favored the research aspect of SDI, but not actual testing and deployment. According to Mrs Thatcher's close aides, she has serious doubts about the scientific feasibility and the strategic logic of SDI. She seems concerned about the "decoupling" effect of SDI, and worried about violating the 1972 ABM treaty. (6:40)

Prime Minister Margaret Thatcher backs SDI because she feels NATO ought not fall behind the USSR in missile defense systems. She did feel, however, that the Soviets will link SDI

to reductions in offensive systems in future arms control talks. She also stated that the US should first enter in negotiations with the Soviet Union prior to deploying a defensive system. (7)

The French Defense Minister expresses a different concern. He claims if the US deploys SDI, Western Europe will have to face the threat from nuclear weapons on its own. He said the deployment of SDI would lead the US and USSR into a "complacency" that "would rid them of any rivalry" in the area of strategic arms. He also feels there is no guarantee that a defense system would lead to a more stable world. Again his main concern, as stated earlier, is an impotent French nuclear arsenal. (14)

Helmut Kohl of West Germany refuses to give full support to SDI because of the upcoming arms control talks in Geneva this month. The Soviets could be tempted to dispose of their SS-20 missiles aimed at Western Europe in exchange for the withdrawal of European based US missiles and the cancellation of SDI. If these negotiations occur, Mr. Kohl does not want to be known as the leader who took away the opportunity for an unproven defensive system. (4:45)

Mr. Kohl gave his support to the US's present research

program, but said this does not mean automatic support if an SDI system were deployed; he will make that decision based on research results. He also stated that if NATO allies participate in the research, they must also receive the technological benefits. "If there is to be European involvement, then there must and will be a technology transfer." He also states that SDI must maintain the US commitment to the defense of its NATO allies. (8)

Despite these concerns by our NATO allies, Europe's cautious support for SDI tells the Reagan administration that the program, when properly explained, is popular. (11) At present the Reagan administration is winning the SDI debate in Europe. Due to the efforts of Mr. Reagan, Caspar Weinberger, and George Schultz, the economic and scientific myths surrounding SDI have almost been eliminated. (11) Yet no one knows the European reaction if the US deploys the defensive system.

Europeans could react to an SDI deployment by moving closer to the Soviet bloc in what has been called the "Finlandization" of Europe. The move might be done largely out of fear of the destabilizing effect SDI would have. Another alternative reaction could be to work with the US to extend the defensive "umbrella" to cover Europe. (10:23) Another

option proposed by French leader Francois Mitterand, a supporter of SDI since its inception, is for NATO to build its own defensive system. (11)

Obviously, the US would not like to see the "Finlandization" of Europe, nor the European reaction proposed by the Congressional Research Service Report. The report states some European leaders fear the deployment of SDI "could spell the end of the Atlantic Alliance." It stated further:

> If the United States continues to hold forth the promise that SDI systems can be extended to cover Europe ... but in ten years' time announces that it can defend only US territory, then some European states might well withdraw from NATO. (1:12)

To avoid European reactions detrimental to the NATO alliance, the US must prove to Europe that SDI can be beneficial to arms control negotiations, that we need their help in the technological and scientific areas, that SDI will protect Europe as well as the US, and that due to the Soviet's advances in Strategic defense, NATO has no choice but to back the US.

In arms control, the Reagan administration believes its plans to research a missile defense system is an effective means of drawing the Soviets to a significant arms control

agreement. The administration feels that SDI is the key in an agreement to reduce offensive weapons since the Soviets have a historic fear of American superiority in technology, and therefore, fear the US will succeed in deploying a defensive system before they do. Some say this fear has drawn the Soviets back to the negotiating table where they may be forced to propose drastic reductions in nuclear offensive arsenals. When such a proposal is made, the US may consider several different negotiating options for SDI, such as sharing technology or mutually deploying comparable system. (12) The main point is that the US must not be, or appear to be, inflexible when linking SDI with offensive weapons recuctions.

Another measure to sway European opinion toward SDI is to do what Mr. Kohl recently proposed -- invite Europe to help with the research. (3) There is a great deal of technological work which must be done involving significant amounts of money. (4:46) The Reagan administration has launched a NATO-wide program to invite members of the alliance to help in research and technology, and to utilize European advances already made in this field. Presently, the European response has been good and shows they are willing to help. (9:55) The invitation to our allies also helps to reduce anti-American feelings already present in Europe. One of the

best ways of reducing the anti-American feelings is by inviting these countries to participate in building defensive systems. Europe has already shown it's qualified to help by their participation in the space-lab and space platform programs. (5:62)

Brigader General Robert C. Richardson III, one of the originators of SDI, has said that Britain and other allies could play a major role in the SDI program and should not assume the US has all the answers. As he stated,

> We [the US] need to look for a team to develop ideas on how to approach the Soviet Union on these matters. There is a tendency to assume that the US has all the answers. We don't and we plead for your views. (13:169)

In reality, it is quite possible that the US has no choice but to let the Europeans participate. Mr. Kohl has claimed that highly industrialized countries such as the European members of NATO "must not be technologically decoupled." (9:56) Mr. Kohl's defense minister, Manfred Woerner, stated that it would be impossible for the US to maintain support from its European allies if the US did not allow them to participate in the technological and industrial areas of SDI. (9:56)

We need to assure the Europeans that SDI will not only protect the US but also Europe. As originally designed, SDI would protect, in graduated steps, first, US forces; secondly, industry and transportation; and finally, the entire US population. However, at a recent NATO conference on defense issues, US Assistant Defense Secretary, Richard Perle, emphasized that SDI would be designed to intercept Soviet SS-20 missiles aimed at Western Europe. (3) In fact, in 1984, the US spent more money on defenses against bombers and cruise missiles than on defenses against intercontinental ballistic missiles, reassuring the Europeans that we are still committed to the defense of Europe. (11)

Obviously, the best defense system is one which would protect against strategic, medium-range and short-range nuclear weapons. If such a system were developed, it would eliminate the threat of the Warsaw pact's conventional forces and theater-nuclear weapons. With such a defense system, the Soviets would still have to contend with our strategic weapons, increasing US deterrence. With a strong deterrence, NATO could use the believable strategy of "deterrence by denial" for the first time since NATO's inception. "Deterrence by denial" would effectively stop an aggressor, such as the Soviet Union, from gaining its objectives, rather than trying to deter aggression with the threat of

massive retaliation. (5:62) To gain our allies' support we must stress that SDI will protect Europe. As Caspar Weinberger stated,

> Contrary to what a lot of people have expressed, if the initiative works, it will work against intermediate range [missiles] as well as intercontinental range [missiles], so there should be no suggestion of decoupling the United States from Europe or anything of that kind. (15)

The final point we must stress to our allies is that the US and NATO have no alternative but to deploy a defensive system. Presently, there is competition between the two superpowers with the Soviet Union already putting a great deal of effort into this field. (5:65) Soviet policy is cautious; they fear taking chances. If the Soviets see an opportunity to expand they'll seize it, however, if the opportunity does not arrive, they'll stay clear of unnecessary risk. Therefore, as long as the United States' present system of deterrence is working, we will be free to deploy SDI. (5:64)

Because of the Soviets' advanced work in missile defense, it's imperative for the US and NATO to work toward deploying a system before the Soviets. If we can deploy first, the danger of war will be reduced greatly. However, if the Soviets gain superiority, it will be extremely difficult to stop Soviet aggression. With an advantage, the Soviets will

have the opportunity to use nuclear blackmail. Consequently, it is in our allies' best, political and military interests to seriously consider the merits of a defensive system. (5:65)

To gain our objective for a defensive system, we must never waver on commitment to SDI. Once a decision to deploy is made, we must stick to the decision. Indecisiveness could cause a break in NATO. We must also remember not to totally forsake NATO's concerns when it comes to making a decision. Lack of consultation with Europe could prove to be costly to the Atlantic Alliance. Together, the US and NATO can embark on a venture for a safer world. Both sides have doubts about the present system of deterrence. If deterrence fails, the result is totally unacceptable. Mutually assured destruction is a doctrine in which a state does not perform one of its most basic functions -- the protection of its people. (5:64) SDI is trying to develop a system to perform this basic duty. However, for a successful system, there must be unity, trust and cooperation between the US and its European allies. If we are willing to work as a cohesive unit, the US, NATO, and the world will benefit.

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THE SOVIET FACTOR IN SDI

by

Cadet Christopher St. Cyr

THE SOVIET FACTOR IN SDI

On March 23, 1983 President Reagan set the course for a possible new direction in the defense and security of our nation with the announcement of the Strategic Defense Initiative or SDI. The SDI program calls for a comprehensive and intensive, long-term research and development program with the ultimate goal of eliminating the threat posed by nuclear ballistic missiles. (1:19) Since the announcement, the Soviet Union has been vehemently attacking the program from all sides. Soviet reaction is of critical importance to strategic planners in the United States and to future decisions regarding SDI. How the United States deals with the hostile Soviet stance may determine the fate of the our SDI system.

THE SOVIETS' CONCERN

The Soviets have made their position regarding SDI very clear. Not a day goes by without a Soviet attack on some issue of the President's plan. The Soviets cite that the proposed system will decrease nuclear stability, cause an arms race in space, violate existing treaties, cost billions of dollars, and ultimately will not work. Herein lies a

fundamental contradiction; if the Soviets genuinely believe the proposed defensive systems will not work, why then do they aggressively try to halt the program?

The answer to why the Soviets want US to stop SDI lies in basic Soviet military doctrine. According to the Soviet Military Encyclopedia, "seizure of the commanding heights in warfare gives the decisive strategic advantage to the side waging the offensive." (11:1) This policy has been actively applied to their own space program, which is eighty five percent military. According to a Pentagon study entitled Soviet Military Space Doctrine, "there has been a concerted Soviet effort to achieve mastery of and crucial superiority in the space medium for military purposes." (11:1) This study, completed last year, when added to other evidence compiled by both intelligence and NASA researchers, reveals a pattern of Soviet research and development and actual deployments of strategic defense systems. (11:1) Since launching Sputnik in 1957, the record indicates a relentless, ongoing, Soviet effort to "seize the commanding heights of space", despite arms control treaties. (11:1)

The Soviet aim, therefore, according to Western intelligence analysis, is first to perfect a variety of systems for "conquering" near-Earth space at altitudes of up to 36,000 km,

ahead of all potential competitors, especially the United States; secondly, to accomplish in space the objective of the Soviet-trained ground forces, namely to "seize the combat initiative, by pre-emption if necessary, ahead of the enemy", achieve crucial victories "at the very start of hostilities", and be prepared to wage a "protracted war;" thirdly, to exploit and complicate the US space effort by mounting a gigantic "disinformation campaign to discredit the US SDI plan;" fourth, to give more meaning to projections found in current Soviet references like the Soviet Military Encyclopedia and the Military Encyclopedia Dictionary since the Soviets intend to hold their lead over the United States in the crucial areas of space research, development, and deployment of space weapons during the present decade and into the 1990's; and finally to

> Take into account the use of outer space and aeronautical vehicles of several types and applications in order to strengthen the defensive might of the Socialist countries... It would be a mistake to allow the Imperialist camp to achieve superiority in the space field. We must oppose the Imperialists with increasingly effective means and methods for exploiting space for military purposes. (11:1)

The Soviet Union fears the American SDI effort since it poses a serious challenge to the most fundamental Soviet strategic goal -- seizure of the commanding heights. There

are good reasons the Soviets fear the American SDI effort. First, the Soviets would definitely lag the US in an all-out fight on the frontiers of technology. Secondly, the enormous costs of a defensive system race would severely strain the Soviets' economy. Thirdly, if the United States succeeds in creating an effective nuclear shield, the Soviets huge investment in long range ballistic missiles would be wasted money. And finally without nuclear parity, the Soviet Union would lose its claim as a superpower. (4:16)

THE SOVIET REACTION

The Soviet Union has a wide range of credible options it can pursue. These options range from simply trying to limit the effectiveness of the US defense system to attempting to completely terminate all US SDI related research. One thing, however is clear -- the Soviet Union will not await the results of American research and passively sit-by while their missiles are rendered obsolete. (7:86) Recent statements by high ranking Soviet officials support Soviet resolve to terminate SDI. Kremlin spokesman Leonid Zamyatin said "as long as the danger of war exist, the Soviet Union will never allow anyone to have military advantage

over it." (5:8) He went on to state "faced with such dangerous plans, the Soviet Union would be forced to build more weapons powerful enough to defeat it." (5:8) These statements are more than idle threats or mere propaganda designed to persuade the West of the futility of SDI. Exactly how the Soviets will respond, and more importantly, what the United States will do to favorably influence Soviet reaction to benefit US strategic objectives becomes critically important.

In whatever manner the Soviets choose to respond, a massive propaganda and disinformation campaign will occur. Their efforts are already well underway. Intelligence and defense experts in the United States believe the Soviets have unleashed the biggest disinformation campaign in their history to stop the American "Star Wars", anti-missile program. (10:1) Although the Soviets' ballistic missile defense system is rapidly advancing, informed defense researchers say the Kremlin would like to stunt President Reagan's SDI research and development program. (10:1) In the opinion of a number of Washington area defense analysts, the American SDI is the main reason the Soviets decided to resume the arms negotiating process. (10:1)

While publicly denouncing the American SDI project, the

Soviets actually fear it. For years the Soviets have been distributing disinformation and propaganda on the "Star Wars" system hoping to discourage any US research efforts while camouflaging their own research and development which includes actual deployment of anti-satellite technology. (10:1)

The Soviet plan targets the American public, which pressures Congress, who has the ultimate control over the SDI program. By fueling both domestic and allied SDI critics with constant anti-SDI propaganda and disinformation, the Soviets are able to reach nearly all segments of the American public, and with significant initial success. However, while research continues, the United States has responded by revealing the Soviet effort and, more importantly, refuting many of the Soviet claims. This concerted US effort must continue.

ARMS CONTROL

One area the Soviets will try to exploit is arms control. The Soviets hope to use the arms control process not for the mutual benefit of both sides, but to further advance their drive for Soviet dominance in space. A decade and a half of

Soviet-American arms negotiations have demonstrated that the Soviets seek to always use the arms control process to assist their drive for military superiority over the West. (3:20) Recognizing this central truth is essential to understanding the current call for negotiations on so-called space weapons. (3:20)

According to the administration's view, the Soviets have an historic fear of American technological superiority and are almost panicked that the United States might successfully develop a missile defense system before they do. (9:G-3) As a result, the Soviets stand to lose a considerable investment in offensive weaponry and find themselves in a strategically vulnerable position. (9:G-3)

Fear, according to the American viewpoint, has prompted the Soviets to return to the bargaining table and may lead to an unprecedented agreement to reduce the number of offensive systems. Critics, however, contend that rather than scaring the Soviets into an agreement acceptable to the United States, the Soviets will only try to match the American research program and trigger an escalation, not a reduction, in the arms race. (9:G-3) In light of Soviet doctrine and their recent statements, this is probably the more likely course. Therefore, are the arms control talks in the best

interests of the United States? The answer lies in our bargaining position and in what we are willing to settle for. America's present position is not to negotate away its anti-ballistic missile, research program. This position is not unreasonable, for SDI is research, and research is permitted by the 1972 Anti-Ballistic Missile Treaty. Additionally, it becomes nearly impossible to verify a ban on research.

The administration has said, however, it will discuss defensive systems after they're developed and before they're operational. Between this vague inducement to negotiate and firm agreement in Geneva, there is a wide gap which the Soviets will try to exploit. (4:20) It makes no sense, the Soviets will correctly point out, to expect a Soviet reduction in their number of missiles until they know whether the remainding offensive force will face a missile-destroying, defensive shield. (4:20) They will pointedly add that the anti-missile weapons explored in SDI will, if fully tested or deployed, breach the 1972 Anti-Ballistic Missile Treaty. So the Soviet Union will probably propose a total ban on space weapons research. They may tie the ban to an uncharacteristically reasonable offer on long range weapons, or to an agreement to scrap medium range weapons aimed at Western Europe in return for withdrawal of NATO's cruise and

Pershing missiles. (4:20)

Consequently, the United States must resist any promise to stop SDI research while seriously negotiating limits on the deployment of a defensive system. (4:20) We should not agree to forgo the use of defensive space systems, since some of the techonology now investigated could at least protect missile sites, and make the world a more stable place.

A second, important question becomes: Is it possible to achieve a meaningful arms control treaty without addressing the problems of verification? Verification is one of the absolute prerequisites for any arms control policy. Since the Soviet Union's interest remain speculative, verification takes on special importance. Western negotiating tactics are based on the speculative definition of Soviet interests, make sense if there is a likelihood of an effective verification. (2:7) Even if the Soviet Union were to accept on-site inspections, which seems most unlikely, the chances of an effective control on research and development remain doubtful. (2:7)

As a result, there is a further problem. Experience from the 1972 ABM Treaty has shown arms control measures reduce the level of funds available for research and development in

the United States, though not necessarily in the Soviet Union. (2:8) So regardless of the problems associated with verification, an arms control agreement prohibiting the production of strategic defense systems would, favor the acquisition of decisive technological advantages by the closed society of the Soviet Union. (2:8) We conclude, therefore, the present arms control negotiations offer little hope of an acceptable outcome.

There are some avenues, however the United States should try to pursue. First, we must admit there will be problems with treaties on weapons which are not yet developed. The United States, and the Soviet Union can not sensibly offer limits on weapons that are not yet invented. It is nearly impossible to negotiate a treaty that would be technically precise to deal with weapons of the future. Therefore, the treaty may not limit much of anything. An alternative might be to modify the existing ABM Treaty in a way that generously reassures the Soviets and the worried Western Europeans. (4:20) At present, the ABM treaty requires 5 year reviews, and a 6 months notice of abrogation. The United States could suggest more frequent reviews of the ABM Treaty to substantially lengthen the notice either side must give before it can break out of treaty. (4:20) This would be a big concession for the United States and it would give the

Soviets plenty of time to increase their own armory before any new American defensive weapons are deployed. (4:20) This, modification would not prevent the United States from exploring the possibility of changing Mutually Assured Destruction into Mutually Assured Defense. Therefore, the objective is not to stop research on defensive systems, for in the long run research may contribute to greater long term nuclear stability.

OTHER FACTORS

Arms control is not the only target of Soviet propaganda. The Soviets are also emphasizing that the proposed defensive system will not work because the Soviets could easily develop cost effective countermeasures to overwhelm or confuse the American defensive systems. These assertions hold some truth, however, a boost phase intercept capability is difficult to counter.

Other critics argue that an effective defensive shield will frighten the Soviets and lead them to launch a first strike before the defensive weaponry becomes effective. Two points tend to disprove this theory. First, the Soviets are already preparing for a first nuclear strike. Their mili-

tary strategists enunciated their intent as early as 1970. (6:B-1) And secondly, a laser beam defense would threaten only incoming nuclear missile. A similiar Soviet defense system would also reduce the fear. of the American nuclear arsenal.

OTHER AMERICAN ALTERNATIVES

In an effort to promote stability, President Reagan has suggested sharing technology with the Soviets and coordinating a mutual deployment. The later is a viable option and will unquestionably promote stability. However, sharing technology with the Soviets is unrealistic. According to Lieutenant General Abrahamson, director of the SDIO, "There is no policy to share SDI related (information) with the Soviets at this time." (8:196) Sharing technology with the Soviets will reveal how our defensive systems work and will enable the Soviets to exploit the system's weaknesses while improving their own system. The cost of upgrading our defensive systems to counter the Soviet challenge would be enormous since design changes after development have traditionally been the single largest cost increasing factor in military acquisition.

The United States must also look at possible long range senarios. Two senarios are possible. First, technological progress on the part of the Soviet Union could reduce the effectiveness of the American system. Secondly, the development of a defensive system by the Soviet Union would enable the Soviet leadership to exploit its conventional and theater nuclear superiority in Europe. (2:8) Not pursuing SDI technology gives the Soviets the edge in conventional, theater nuclear, and strategic nuclear forces.

CONCLUSION

Would the pursuit of defensive technology be in the best interests of the United States when considering the possible Soviet reactions? The answer is, of course, a resounding yes. If the Unites States fails to gain the upper hand in this military technology, it is certain the advantage will pass by default to the Soviet Union, which will not hesitate to develop its own defensive system. (2:8) If they succeeds in developing a defensive system, it is equally certain the Soviet Union will use its first strike capability to prevent the United States from developing a comparable defense system. According to Werner Kaltefleiter:

> Competition in the development of a system of strategic defense can not be avoided. The Soviet Union has already devoted much time and effort to its work in this field. Furthermore, relevant arms control measures can, by definition, never be fully reliable. In reality, the West has no alternative. (2:8)

He continues and argues for a determined Western effort to develop and deploy defensive technologies ahead of the Soviets:

> If the democracies were to gain superiority in the field of strategic defense, the danger of war would be reduced accordingly. Should this superiority pass to the totalitarian dictatorships, on the other hand, the risks of nuclear blackmail would be acute. In view of the additional advantages enjoyed by the Warsaw Pack, especially those in the conventional field, the same risk would exist were both sides to develop defensive systems simultaneously. As a result of the conventional imbalance, the existence of a balance in defensive systems would not have the advantages of a unilateral strategic defense capability on the part of the United States. (2:8)

Hopefully it is now clear that the United States should pursue defensive technologies. Should the United States gain an advantage in the development of a defensive system, the credibility of Western deterrence will be greatly enhanced, even if the system failed to guarantee complete protection. The Soviet response is a major factor in our decision, but one we can certainly deal with.

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SURVEILLANCE, ACQUISITION, TRACKING AND KILL ASSESSMENT

by

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3 May 1985

ABSTRACT

Surveillance, acquisition, tracking and kill assessment (SATKA) is vital for the Strategic Defense Initiative (SDI). Without SATKA capability the weapons of SDI have no effect. If a target cannot be found, the weapons cannot be used. Additionally, wasting time and energy on an already nullified target drastically decreases the effectiveness of a weapon system. We have not given SATKA, as much attention as lasers, kinetic energy missiles, and particle beams; perhaps we ought to.

This paper will discuss our group's research in the SATKA area, specifically the conceptualization of constellation orbits for SATKA sensors. For a specific sensor system, we developed orbital parameters that optimize coverage while considering survivability and cost. We achieved our results by using computer simulation to help find the optimal orbital plane. We then used the orbital plane to optimize a three dimensional constellation.

SATKA

To reduce the complexity of finding an optimal constellation for SATKA sensors, we made several assumptions to fit the scope of this research. While the assumptions do reduce the complexity of the problem, they do not significantly decrease the meaning of the results.

The first assumption deals with the sensor. We gave the low-level, above-the-horizon, scanning, infrared sensor an unlimited range. This assumption is reasonable since we are dealing with near-earth orbits. We also assumed the sensor is capable of discriminating and tracking every object in its field of view and cannot become saturated with targets.

Assumptions made in the geometry of the earth and atmosphere are that the earth is a perfect sphere and the atmosphere is a thin-shelled sphere surrounding it. These assumptions allow us to use geometric and trigonometric relations in modeling orbital cases.

We also made some assumptions about the sensors' orbit and the ICBMs' parameters. The orbits are ideal, two-body, and circular without perturbations. For the ICBM we use nominal

parametric values from the MX missile. We obtained these values from Major Robert S. Fraser, Department of Astronautics, United States Air Force Academy. We feel that the MX parameters are similar to those of Soviet ICBMs that may appear in the near future.

To limit variables considered in optimization, we assumed perfect tracking and coordination between sensor platforms. Since coordination will be a concern regardless of the number or altitude of the platforms, tracking and coordination did not influence our approach as did other parameters.

Finally, we considered physical threats and aggressive actions against the space segment only. We did not consider hostile actions taken against ground-based facilities or nodes of communication.

APPROACH

Our approach to this problem involved two major steps. In the first step we found the orbit constellation that minimized the undetectable air space. In the second step we determined how the constellation's effectiveness varied by changing such elements as the number of planes, inclination,

and the stagger angle. By changing orbital parameters, we found the "best" orbital constellation for an above-the-horizon, infrared, SATKA sensor.

To find a single-plane constellation minimizing the undetectable space, we developed a computer program. This program uses a two-dimensional model of the earth and calculates the undetectable area. Since the undetectable area is directly proportional to undetectable volume, our results were useful in determining the minimum undetectable space. The Department of Mathematics at the United States Air Force Academy validated our mathematics and geometry we used to find the undetectable area.

As we varied numbers of satellites per orbital plane and the satellite altitudes, the program calculated the undetectable area. We ran the program for an orbital plane with three to ten satellites at altitudes of 185 KM to geosynchronous. When picking the best constellation, we first considered the altitude. If the altitude of the orbit was below the burnout altitude of the missile, we considered the constellation since we assumed downward-looking, infrared sensors would track the missile until burnout. If the altitude passed the requirement, we chose the number of satellites in the constellation that resulted in the least amount of

undetectable area. We also considered the orbit that was most survivable and cost efficient.

After choosing the single-plane constellation which best met the above criteria, we applied several of the orbital planes to the spherical earth. Using the program BATTLE, we varied the inclination, the number of satellites, and the stagger angle -- the angular difference between subsequent satellites in adjacent orbital planes in the constellation. By varying these three parameters, we determined which reentry vehicles could be detected and by what satellite. We also found the length of time a satellite could see a given reentry vehicle before losing visibility. With this information, we were able to choose the most effective constellation -- the constellation that let the fewest reentry vehicles through. We were also able to reduce the number of key satellites, those which detected an unequal share of reentry vehicles, to spread the detection evenly among all satellites and to prevent saturation of the system.

In short, we minimized the undetected areas and system cost, and maximized the detection efficiency and survivability. Thus, we were able to pick the best constellation for global coverage.

THEORY

The sensor system dictates the type of orbit needed. In our case, we chose to examine orbits for an infrared sensor. Since a high frequency, infrared sensor can detect a launched booster, a standard geosynchronous orbit with three operational satellites will be sufficient for boost phase coverage. Conversely, the radiation distribution of reentry vehicles requires low-frequency, infrared detectors with horizon scanning since the earth's background radiation would mask the reentry vehicle's signature. Therefore, the problem becomes one of finding the maximum earth coverage for horizon scanning orbits. To start, the two dimensional coverage of a single-plane must be determined. This coverage is calculated by using simple geometry to find the area of the undetectable regions -- the regions the satellite can not "see" because of obscuration by the earth's infrared background. The area of the undetectable region is found by determining the area of the polygon formed by the line of sight from the satellite to the lim of the earth, and subtracting the area of the circle representing the earth and its atmosphere. To find the area of the polygon we need the number of satellites in the ring, and the altitude of the satellites.

Once the area is found, we need to make some minor adjustments to the undetectable areas due to the number of satellites and their altitudes. The adjustments are necessary because of the spacing between the satellites caused by the number of platforms in the orbital plane and the height of the orbit. The changes taken into consideration, reduce the overlapping coverage caused by the number of platforms and their altitude.

In our analysis we examined five cases. In each of the cases, we programmed the equations we derived to obtain altitude and undetectable area over a range of satellite numbers and altitudes for two-dimensional coverage. The program's inputs are the number of satellites in the ring, a range of values for the orbital radius, a step-size increment for the range, and the altitude of the atmosphere. The program iterates on the orbital radius and outputs the undetectable area and altitude for each step. The program, which accomplishes this is ENGR495. It is written in FORTRAN 77 on the Burroughs 6900 computer at the Air Force Academy.

We took data on orbits containing between three and ten satellites, and for altitudes ranging from 70 nautical miles to geosynchronous orbit. We selected the number of

satellites based on expected constellation parameters, and we chose altitudes based on the operating range of normal earth-sensing systems. Our program assumes a spherical earth and atmosphere, and circular orbits for the satellites. The altitude of the atmosphere was set at 50 nautical miles.

To gather data about the effectiveness of the constellations designed by the group, we used the program BATTLE to determine if a reentry vehicle was visible to a sensor platform. The program BATTLE also resides on the Burroughs 6900 at the Air Force Academy and is written in FORTRAN 77.

DISCUSSION

We encountered several problem in developing the mathematical methods for solving our constellation optimization problem, and left some areas which yet need to be investigated. The first problem area involved developing the theory for two-dimensional orbital coverage. We found drawing precise diagrams to visualize the problem aided in determining the proper angles. Since we also had to consider the relationships of altitude and the number of satellites, we used a number of diagrams to help in our examination.

After developing the theory we faced the problem of validation. After confirming the mathematical method of geometry with Major Petros, Department of Mathematics, United States Air Force Academy, we examined the results. By using a number of different cases at appropriate points, we were able to validate our program and continue our research.

We had to modify the program BATTLE to suit our needs. The modification consisted of changing the subroutine BATVIS to simulate a sensor that could detect objects above the horizon and not obscured by the background radiation of the earth. The output was also modified so only the data we needed was printed. With these modifications, it was simple to extract orbital data from the constellation we designed for optimum visual coverage.

Due to our time constraints, we made some simplifying assumptions and recommend these areas for further research. First, we recommend a perturbation study to determine how long the sensor satellites would remain in an orbital position that would be of value. Third body and J-2 effects are the dominant perturbing forces and require the greatest research.

Secondly, we see value in a more thorough study into the

coverage offered by different orbits. For example, better regional coverage may be obtained by using elliptical or molniya orbits rather than circular ones.

Thirdly, we assumed our sensors were ideal with unlimited range, perfect battle management, unlimited target acquisition, and impervious to Van Allen radiation. This assumption is valid for an initial conceptualization, however, more realistic data could be generated using actual sensor parameters. For example, our sensors may not be able to handle the background radiation associated with the selected satellite orbital altitudes.

Finally, we feel a detailed cost analysis is valuable in determining the number of satellites actually needed as opposed to the number needed for 100% global coverage. Many times cost constraints, not technological constraints, determine the efficiency a system. If the desired efficiency is too expensive to acquire, the system may never be deployed even if it is technically possible.

RESULTS

The results of the two dimensional analysis are compiled.

Number of Satellites in Orbital Plane	Optimum radius (DU)	Minimum Undetectable Area (DU^2)
3	6.62	.444
4	2.7	.178
5	1.58	.123
6	3.82	.076
7	1.3	.057
8	5.22	.042
9	2.98	.033
10	2.14	.028

As expected, coverage increases with an increasing number of satellites, but there is no apparent trend of orbital altitude with respect to satellite number.

We selected an optimal solution from the orbital planes having a minimum orbital altitude below the MX burnout point. Consequently, we were left to decide whether to chose from an orbit with 8, 9, or 10 satellites. We selected as the optimum solution, an orbit with 9 satellites because boosting nine satellites to 2.98 DU was more cost effective than boosting 8 satellites to 5.22 DUs. Likewise, boosting ten satellites to 2.14 DUs, an altitude nearly the same as 2.98 DUs, required the cost of building and launching one additional satellite.

Once we determined the nominal case, we ran the program again to refine the optimal solution parameters. We used a small stepsize in a limited range around a radius of 2.98

DU. We found we could reduce the radius to 2.8 DU with only minor changes in the undetectable area and altitude. Consequently, the optimum solution for our two dimensional problem is an orbit with 9 satellites at a radius of 2.80 DU's and an undetectable area of .034 DU^2.

The two dimensional results gave us the ideal constellation plane. Next, we concerned ourselves with placing this plane around the earth for the best global coverage. We looked at locating one of these orbital planes at various inclinations around the earth. The inclinations we considered were 45^o, 60^o, and 90^o. To pick the best inclination for the plane, we used BATTLE and looked at the target acquisition time and the number of platforms able to detect the reentry vehicle. The orbital plane that acquired targets the fastest, kept them in sight for the longest time, and had the greatest redundancy was considered the best orbital plane inclination.

The planes with inclinations of 45^o and 60^o gave exactly the same results for acquisition times and redundancy. Thus, from the two, we chose the smaller inclination since it is easier and cheaper to insert satellites into a lower inclined orbit.

The single-plane constellation seems like the obvious answer. It is inexpensive, simple, and seems to sufficiently cover the globe for our test case. However, a single-plane leaves two conical undetectable areas perpendicular to the orbital plane. Since it's possible one of these cones could be over a launch region during an attack, a simple solution is to use two planes with a separation of 90^{o} in longitude of ascending nodes. Thus, with two planes you could effectively eliminate all undetectable areas. Since the 45^{o} inclined, single-plane was the optimum orbit in the previous discussion, two planes with their ascending nodes spaced at 90^{o} would undoubtedly give the best results for three-dimensional positioning.

CONCLUSION

On the basis of our research presented in this report, we determine the optimum SATKA orbits as consisting of nine evenly spaced satellites in a circular, 45^{o} inclined orbit at an altitude of 1.80 DU. This orbit provides adequate, survivable coverage at the least cost. To ensure nearly absolute coverage, a second ring with the same characteristics, but with the ascending node offset 90^{o} from the first, may be added. The decision on using the second ring rests

on the question, "Is the additional coverage worth the extra money?" Regardless of whether one or two rings are used, these constellations provide adequate mid-course and post-boost SATKA coverage using low frequency, infrared, above-the-horizon scanning sensors.

A STUDY ON OPTIMIZING A SPACE-BASED LASER CONSTELLATION

by

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and

Cadet Jeffrey S. Henry

6 May 1985

ABSTRACT

The goal of this report is to explore the effects on the performance of a space-based laser system by varying the time and laser parameters. We used an already-developed, space-based laser, computer model for our study. This model is called HELSTAR and is described by its designers as:

> A system parameter model which allows space-based laser ballistic missile defense planners the capability to select weapon, missile, and battle management parameters and determine an approximation of the minimum number and orbital configuration of lasers required to defend against various ballistic missile attack scenarios.

HELSTAR, using a boost-phase intercept scenario, will optimize the space-based laser constellation to meet certain user-supplied criteria. It optimizes the constellation by running multiple scenarios of seven battles each. Each scenario brings the constellation closer to optimization. There can be as few as two scenarios, or as many as eight, depending on the success criteria desired by the user.

We would like to thank Major Salvatore Alfano, Department of Astronautics, United States Air Force Academy, for his extensive assistance with the program.

LASER PARAMETER VARIATIONS

by

Cadet Terrance A. Leary

LASER PARAMETER VARIATIONS

The objective of my report is to study the effects of laser parameter intensity, spot radius, and reference range. With my research and results of the study, I drew conclusions concerning the technological feasibility of directed energy weapons for ballistic missile defense and the best manner of pursuing such technology in future research.

ASSUMPTIONS

The following assumptions apply in the study of varying laser parameters. The program HELSTAR uses a molniya-type orbit with an inclination of 65 degrees, a perigee altitude of 500 km, and an apogee altitude of 1000 km. This orbit describes either a space-based laser constellation or a constellation for reflective battle mirrors.

All laser firing is done perpendicular to the target to maximize spot size. To simplify the problem, the program assumes perfect laser pointing and determines whether to fire a weapon based on kill assessment rather than range. Therefore, it considers atmospheric effects and fires when it has the best chance of a kill. A missile can be targeted

by more than one weapon as long as all other missiles in the weapon's range are being fired at. Additionally, only sea-launched ballistic missiles and ground launched cruise missiles passing above a certain altitude are possible targets.

Results are based on monte carlo simulations which use a clock to provide a random number. Based on the random number, the battle is started at different points in time. Seven different battles are run with the high and low results dropped and the other five results averaged.

For this study we assume the weapons have authorization to fire from the time the missiles reach a specific altitude until they are destroyed. We assume a missile is destroyed if the laser can achieve an on-target time of 10 seconds. On-target times of less than 10 seconds are considered partial kills.

THEORY AND PROCEDURE

After I familiarized myself with the parts of the HELSTAR program, I varied three different laser parameters and examined the simulated results. I varied the laser intensity from 15,000 to 100,000 watts per centimeter squared, the

spot radius from 100 cm to 10 cm, and the distance between laser and target from 100 to 1000 kilometers.

After gathering all the simulated data, I analyzed the results and drew some conclusions. To help analyze the data I plotted the various parameters against the average number of kills per weapon. From these plots I studied the trend of the data and based my conclusions on these results and on my research of the most recent developments in laser and directed energy weapon capabilities.

DISCUSSION

HELSTAR was written for space-based lasers, but we can easily use the program to simulate a system of ground-based lasers and space-based mirrors. For directed energy weapons we assume a pulsed output. Therefore, the destructive effects result from either ionization of electronics or from a shock wave caused by a repeated impact of the energy beam. The shock wave can create a hole or propagate cracks which will destroy the guidance system. (4) Both ionization or structural damage due to shock waves make the reentry vehicles more vulnerable to destruction.

By varying intensity, the analysis pointed out that an effective system would have to use lasers with great amounts of power. At present the Novette laser at the Lawrence Livermore National Laboratory (LLNL) is the only laser able to achieve the power required. The laser has an intensity of 5×10^{13} watts/cm^2 (7:56). This laser however, produces visible light, which is easily reflected, for a very short time. In other words, it cannot be used as a defensive weapon because of its characteristics, size and weight which preclude it from being launched into space.

The only other lasers that appear to be approaching the needed power are x-ray and tunable free electron lasers. Both of these are predicted to have 80 megawatt of power. (5:1300) Considering the huge advances made in lasers to date, since their discovery in 1967, the necessary power and intensity levels may be achievable in the near future. At present the greatest obstacles are weapon size and coherency of the beam as it propagates through space and the Earth's atmosphere.

From the results of the spot radius analysis we discovered that decreasing the size of the beam had little effect. This was an expected result because intensity is what relates directly to destruction and since intensity was held

constant the effects did not vary. Therefore, we were, in effect, simultaneously decreasing power while holding intensity constant. If we change the algorithm to keep both intensity and power constant, changing the spot radius should show less effectiveness. However, this analysis was not useless; it demonstrated lower energy weapons and tighter beams have no advantage since intensity is a function of power and spot radius.

The other parameter I varied was the range of the weapon. The results we obtained approximated a line and had a much steeper slope than any of our other results. Varying range seemed to achieve a much higher kill-to-weapon ratio than by varying any other parameter. The higher kill-to-weapon ratio resulted from a greater beam coherency for shorter distances. The ranges I considered are realistic considering the Antigone project is hoping for a range of almost 1700 km. (2:18). Thus, from our analysis, we determined we must increase range capability to improve a laser weapon system, and it seems easier and less expensive to develop ways for increasing range than to increase intensity.

The major problems associated with increasing range are increasing beam coherency, preventing atmospheric absorption, and preventing bending due to magnetic fields. These

problems are currently being researched at the LLNL. The laboratory's explanation of a program to increase range by canceling magnetic effects is:

> The electron beam follows an ionization channel created in low density air with laser chemical tracking forces overcoming bending forces of the earth's magnetic field. The beam has sufficient range for such a weapon system to insure destruction of ballistic missiles and post boost vehicles (2:18).

Another area of research is maintaining electron beam coherency in the vacuum of space. The process uses a laser to ionize gas and create a positively ionized channel which cancels the effects of a space charged field and allows the electron beam to follow the channel (2:18). This process could have applications for charged particle beams and possible operations in the Van Allen radiation belts.

Finally, we must consider beam propagation through the atmosphere. Certain wavelengths such as 3.8 microns will easily propagate. (3:26) However, lasers at these wavelengths do not show the same promise as the shorter length x-ray and free electron lasers. As an alternative to shorter wavelengths, the technique of hole-boring is being developed. Hole-boring uses a rapidly pulsed laser. The first pulse heats the air causing it to expand and create a low density area. The next pulse is timed to fire before

the density increases thereby passing through the air with less absorption. By creating thousands of correctly spaced pulses a laser can develop a hole in the atmosphere (4).

CONCLUSIONS

From the results in this part of the project we can draw some very definite conclusions. First of all, it appears the technology for a BMD system is not presently available, but is not out of reach. From the analysis, the single best method of obtaining this technology is research in the area of increasing laser range. As a secondary consideration we can try to increase intensity by creating beams with higher powers and smaller spot radii. From research we see that the most promising weapons available are the x-ray and free electron lasers. The ideal weapon however, would be a free electron laser, tunable in the x-ray region, such as the lasers at the LLNL and the Lawrence-Berkley Laboratory (LBL). The reason short wavelength lasers are more promising is because of their higher intensities and ranges in the atmosphere and because they cannot be totally reflected by an ICBM as a protective method. The overriding problem with lasers is their size and weight which at present prevents them from being based in space. This problem suggests a

system of ground-based lasers with geosynchronous and low orbiting battle mirrors. Unfortunately, this concept develops a new set of problems such as the tenths of a nanosecond pointing accuracy required (2:19). A decision on a system of this type is not expected until 1993, but our research indicates a ground-based laser with reflective mirrors to be the best path for future research.

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TIME PARAMETER VARIATIONS

by

Cadet Jeffery S. Henry

TIME PARAMETER VARIATIONS

HELSTAR is a program designed at the Air Force Institute of Technology to model a space-based laser constellation for ballistic missile defense. It's capable of optimizing a constellation given certain parameters, and a user-defined constellation and intercept type. It's also flexible enough to change nearly all of the battle management, laser, and missile parameters. HELSTAR was written by Captains Michael L. Hunter and Joseph Wysocki, Air Force Institute of Technology, in 1983, and extensively modified by Capt Salvatore Alfano and Cadet Bruce Magoon, United States Air Force Academy, in June 1984.

My purpose in using HELSTAR is to determine the effectiveness of a space-based laser constellation by varying time parameters. These time parameters include release authority time, amount of fuel per laser platform (in seconds), and retarget time. Release authority time is the amount of time between detection of launch and authority to release a laser attack, while retarget time is the amount of time a laser needs to acquire a new target after killing the present one.

While varying these parameters, I explored the effects on both boost-phase-only intercept, and boost and mid-course

intercept. For the boost-phase-only intercept, the program optimized the constellation for a given a success criterion -- a certain number of missiles killed, while for the boost and mid-course intercept, the program used a user-defined constellation without optimization, but with the same success criteria.

ASSUMPTIONS

To understand the results of the computer simulation, it's nessecary to understand the inherent computer program assumptions. In addition to these, I made assumptions concerning some of the parameters in the program to make the simulation meaningful.

The HELSTAR program assumes all system components, other than the lasers, are ideally effective. These include the surveillance, acquisition, tracking, pointing, and kill assessment system components, and the command and control segment. Ideally effective implies that the system components work exactly as intended and without error. These assumptions are necessary to avoid excessive program complexity arising from trying to model more than the laser system.

HELSTAR uses a monte carlo simulation to determine initial laser platform positioning at ICBM launch. This facilitates the realism of a surprise Soviet first strike.

The program also assumes the space-based lasers have no active maneuver capability to defend against anti-satellite activity; therefore, the program assumes the lasers cannot be destroyed. Even though they cannot be destroyed, they have a user-defined failure rate, which will be addressed later in this section.

Since orbital perturbations occur over long periods of time and since battle encounters are very short, approximately 5 minutes, the program assumes orbital rates of change to be zero.

My report assumes all laser weapon parameters are constant, with the exception of the maximum space-based laser fire time, which is one of the time parameters I vary.

In each scenario, the Soviet Union launches 1000 missiles simultaneously from ten different bases in the USSR. In the boost-phase-only intercept scenarios, the locations for the first four launch sites are taken from information in Soviet Military Power 1984, while the last six sites are spaced

along a latitude of 55 degrees. In the boost and mid-course intercept scenarios, all ten bases are spaced along 55 degrees latitude, as set by Hunter and Wysocki. The boost-phase-only intercept trials, target ten widely dispersed targets in the United States, while the boost and mid-course trials, target locations in Washington state, as set by the designers of HELSTAR. Each missile is assumed to be of the same type, so that the program can use a single boost-table for each missile. The boost-table contains the altitude and range of the missile at specified times.

The number-of-missiles-to-be-killed parameter is the number of missiles that must be hit for the simulation to be successful. I set the variable to 1000 for each scenario so that the program will optimize the constellation for 100% effectiveness.

The space-based laser constellation is an inclined, elliptical orbit. The inclination is set at 63.4 degrees, which, in reality minimizes orbital perturbations. The perigee altitude is 500 km and the apogee is set at 2972 km for the boost-phase-only intercept model, and 1000 km for the boost and mid-course model.

The time-of-launch parameter is defined as the release

authority time or the time from launch to the time authority is given to release the laser attack. This parameter is the one most often changed.

The user can change the reliability of the lasers by changing the probability-of-first-fire and the probability-of-fire-at-end parameters. I set both of these to .9, meaning a 10% chance of failure the first time the laser is used, and a 10% chance of failure each time thereafter.

APPROACH AND PROCEDURE

The first parameter I varied was the release authority time or the time-of-launch. My goal was to find a relationship between the delay time and the number of missiles killed. I held all other parameters constant. For the boost-phase-only model, the delay time varied from 0 to 300 seconds in 30 second increments, and for the boost and mid-course model, 0 to 600 seconds in 60 second increments. In both cases, retarget time was the original program value of one second. A subsequent series of 0 to 300 seconds was run for the boost-phase-only model, with retarget time equal to 2 seconds. The constellation consisted of 7 rings of 6 lasers per ring or 42 platforms.

For the boost and mid-course model, I held the time-to-launch at zero, while I varied the fuel load time from 200 to 300 seconds in 20 second intervals. The constellation was constrained to 6 rings of 6 lasers per ring or 36 total platforms.

After tabulating all of the raw output data from the different scenarios, I analyzed the results by using a curve fitting program with plotting capability. The program can fit the data to a linear, logarithmic, power, or exponential function and plot the data points on the fitted curve. The program also calculates for each function the-root-mean-square error (RMSE) or the mean absolute distance from each actual point to its corresponding fitted point. The RMSE indicates the exactness of fit and serves as a comparison of the relative accuracy for each fit.

RESULTS

In analyzing the data, I discovered some interesting relationships. When I compared delay time with the number of kills in the boost-phase-only scenario, I found what seems to be a combination of a linear and exponential fit. The RMSEs were nearly identical, and the curve had a good

exponential fit at the beginning of the battle and a good linear fit closer to the end. This suggests that small increases in release authority time could be significantly detrimental to kill rates early in the battle, while large increases will be somewhat less detrimental.

The next relationship I found is between release authority delay time and the number of space-based lasers required for each optimization scenario. A linear curve with a constant slope appears to be the best fit. Consequently, as delay time increases, so does the number of satellites needed for an effective laser constellation.

Variations in release authority time delay do not seem to affect the battle duration, the number of lasers used per battle, or the amount of fuel used per laser. Furthermore, the number of kills per laser per battle remains essentially constant. If you consider the number of kills per laser, without considering the number of lasers used in each battle, the data tends to fit a sharply decaying exponential curve.

In changing the retarget time from 1 to 2 seconds for the boost-phase-only intercept model, the rate of exponential decay for delay time versus number of kills is

correspondingly higher. We can deduce from this fact that increasing retarget time for the laser will greatly decrease the number of kills as delay time increases.

Switching attention to the results of the boost and mid-course scenarios, I found only one significant relationship of those tested. There is a substantial decrease in the number of missiles killed as the laser fuel load decreases. The data roughly fits a linear curve with a constant slope.

All other relationships tested including the number of lasers used per battle, fuel used per laser, and battle duration, proved to have no correlation with changing the fuel load. The three relationships just mentioned, along with the number of kills versus the delay of release authority time, yield no significant results for a boost and mid-course system.

CONCLUSIONS

For a boost and mid-course antiballistic missile system as modeled by the HELSTAR program, the only parameter tested that significantly changes the constellation's effectiveness is the laser fuel load or the fire time. A constant ratio

of fuel per missile killed can be determined from the results.

For a boost-phase-only antiballistic missile system, delaying release authority time significantly decreases the number of missiles killed. It also increases the number of lasers required to meet success criteria. Also, a linear increase in the number of seconds required for retargeting a laser causes an exponential decrease in the number of missiles killed.

Therefore, the parameters, in the order of importance, which must be considered to ensure maximum effectiveness of any space-based antiballistic missile system are: first, the release authority time must be kept to a minimum; secondly, the fuel load or fire time of a laser must be maximize; and thirdly, the laser retargeting time must be minimized.

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